CHANGES IN THE ECONOMIC USE OF LAND IN THE VICINITY OF TRIPOLI

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ABSTRACT

This study relates to 1400 square kilometres in the vicinity of Tripoli, Libya, in which irrigated, and semi-irrigated, settled agriculture was being carried out in 1968, and in which major changes had taken place in the agricultural geography of the area following the discovery and exploitation of the country's petroleum resources.

The physical character of the area and its economic and historical background are first outlined.

The main part of the thesis is concerned to confirm a number of propositions, namely that there has been an intensification and extension of agriculture through the development of irrigated farming and at the same time a lessening of the separateness in the characters of the 'traditional' and 'ex-colonist' farms. The only marked differences between the appearance and character of traditional Libyan 'gardens' and the holdings set up during the Italian administration (1912-1943) still evident in 1968 will be established and afterwards shown to be subject to considerable modification.

A second group of propositions, concerned with crucial constraints on the continued development of irrigated agriculture, are presented in sections treating the inadequacy of underground water resources, the difficulties attendant on the upward trend in agricultural wages and the problems of financing further viable agricultural development.

The evidence presented to confirm these propositions has been derived from personal fieldwork carried out in 1967 and 1968, when the author was concerned with aspects of the organisation and administration of the Libya University - London University Joint Research Project. Material collected through the field surveys of the project, both published and unpublished has also been included.

Much emphasis is given to photogrammetric techniques in that satisfactory comparative data for earlier periods were only available in photographic form. Statistical analysis by multi-variate and other techniques has been incorporated in various sections, notably that relating to the 'separateness' of the farm types.

ACKNOWLEDGEMENTS

The good will of many individuals has made the completion of this study possible.

In Libya the University of Libya made my residence in the country both possible, comfortable and effective, and provided accommodation and transport as part of the Libyan University - London University Joint Research Project (1967-1970) directed by Dr K. S. McLachlan and Dr M. M. Buru. The latter was extremely strong in support as was Dr A. Dagman and Ess. A. al Tayyar.

Libyan students very generously assisted with field enumeration and I should like to thank especially Hasan Amari, Mohamed Ali Da'bub, Abdelhafez Sha'ban Shaileh, Sadiq Dahmani Assti, Mohamed Suessi, Ramadan Kharafallah, and Suliman bu Sueder. A number of farmers spared considerable time in providing information, and I am very grateful to Ess. Said Budheir, Ess. Amari, Ess. Mohamed Oan, Sgr. E. Trigila and Sgr. D. Paulini for such help.

Members of a number of Libyan ministries and departments provided data essential for the completion of the study. Ess. Issa Ghiblawi and Ess. Muftah Tarabullisi were very helpful in the Ministry of Planning and Development, and Ess. Fituri Degais in the Department of Soil and Water Conservation were especially generous. I should also like to thank Ess. Salem Zenaty of the library of the Bank of Libya for his always ready assistance.

Other friends in Libya extended important help and I should like to mention Ess. Abdullah Sassi, Ess. A. Tawil and Ess. Gemal Areibi.

The photogrammetric content of the study was made possible through the provision of existing photography by Fairey Surveys Ltd., Aero Exploration and Hunting Surveys Ltd., and the two last of these companies also flew material especially for the study in 1968 on advantageous terms. Mr L. Williams of Hunting Surveys Ltd. in Tripoli was especially helpful. The plotting of the survey field work was very kindly completed in the Photogrammetry Department of University College London by Mr E. H. F. Wickens and Mr K. B. Atkinson.

I should like to thank the British Petroleum Company Limited as one of the financial sponsors of the Joint Project, and also for the clerical and other help extended from time to time in Tripoli. A special favour was extended by Mobil Ltd. in copying wages data kindly provided by the proprietor of a large farm near Tripoli.

Invaluable guidance was obtained from Dr C. Grey, Head of the Geology Department, University of Libya with respect to the hydrological aspects of the study, and data processing was much expedited through help from Dr K. E. Rosing assisted by Mr P. Cox. The IBM 360/60 computer of University College London was used for data processing.

I should like to thank Rosemary Brown very warmly for treating the matter of typing the thesis as something of importance and for completing it accurately despite the pressure.

Finally I should like to record my thanks to the late Dr J. H. G. Lebon who supervised my research until his untimely death in December 1969. Subsequently I have been encouraged towards completion by Professor C. A. Fisher and for this support I am most grateful.

ABBREVIATIONS

B.M.A.	....	British Military Administration
cf.	....	compare
°C	....	Degrees Celsius
Co	....	Company
FAO	....	Food and Agricultural Organisation
ha.	....	hectare
kgs	....	kilograms.
km	....	kilometre
km^2	....	square kilometre
£L	....	£ Libyan assumed to be equivalent to £ Sterling 1.14 in 1968.
LULUJRP	....	Libya University - London University Joint Research Project
m	....	metres
m^2	....	square metres
m^3	....	cubic metres
mm.	....	millimetre(s)
mn	....	million(s)
NASA	....	National Agricultural Settlement Authority - a department of the Ministry of Agriculture.
No.	....	Number
SOAS	....	School of Oriental and African Studies
U.N.	....	United Nations Organisation
U.S. & U.S.A.	....	United States of America

UNITS OF MEASUREMENT & EXCHANGE RATES

Metric units have been used throughout this study, including those for length, area and mass.

Values have been quoted in £ Libyan. One Libyan pound was equivalent to £ Sterling 1.14, and to US $ 2.8 in 1968. Prior to the devaluation of the £ Sterling in 1967 one £ Libyan was equivalent to one £ Sterling.

REFERENCES

NOTE

References are signified in the text by serial numbers, commencing at number (1) in each chapter. These are listed, together with those for chapter one, on page 244 and those for other chapters on the following pages.

A limited number of explanatory footnotes have been included. These are signified by asterisks, thus, * or ** according to the number of footnotes on the page.

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APPENDICES - CONTINUED

APPENDICES - CONTINUED

LIST OF FIGURES

Figure numbers consist of two or three parts. The prefix designates the chapter. In chapters 1, 3 and 5, the second digit indicates the serial number of the figure within the chapter. In chapters 2, 4 and 6 the second digit indicates the section of the chapter in which the figure appears and the third digit is a serial number within the section. A uniform numbering system has been used for figures and tables in the respective chapters.

LIST OF TABLES

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REFERENCES

References are listed according to the serial numbers used in the text.

Each chapter commences with a serial number '1'.

CHAPTER 1

INTRODUCTION AND STATEMENT OF THE STUDY

1.1 Introduction

Libya has undergone rapid economic change* as a result of increasing oil revenues. Crude oil exports rose rapidly after their commencement in 1961 at the rate of about 25% per annum, so that by 1969 Libya had become the fifth oil producing country in the world, after only eight years of production. The gross domestic product at factor cost was estimated to be £L 152.5 million in 1962 and by 1968 this had grown to £L 1095.3 at current prices.[1] (cf. £L 182.7 million in 1962 with £L 850.8 million in 1968 at 1964 constant prices)[2]

All sectors of the economy were affected by the improvement in the national income, and it has been the purpose of the research outlined in this thesis to identify developments in the agricultural sector between 1960 and 1968, and statements on this subject will be made in the following paragraph, and evidence assembled to confirm them. Taken together these statements indicate briefly the most important characteristics of agriculture in the 1960-68 period, in the area around Tripoli, which has always been, and remains, the most important area of irrigated farming in Libya. 64 per cent of irrigated farms of Western Libya were shown to be in the Muhafadat of Tripoli and Zawiyah in the sample survey carried out by the Libyan-London Universities Joint Research Project in 1968.[3] In addition Western Libya had 87% of the irrigated area of Libya, and 78% of irrigated holdings.[4] To examine irrigated farming near Tripoli is, therefore, to look at the most productive agricultural area of Libya, both in terms of production per hectare and total output.

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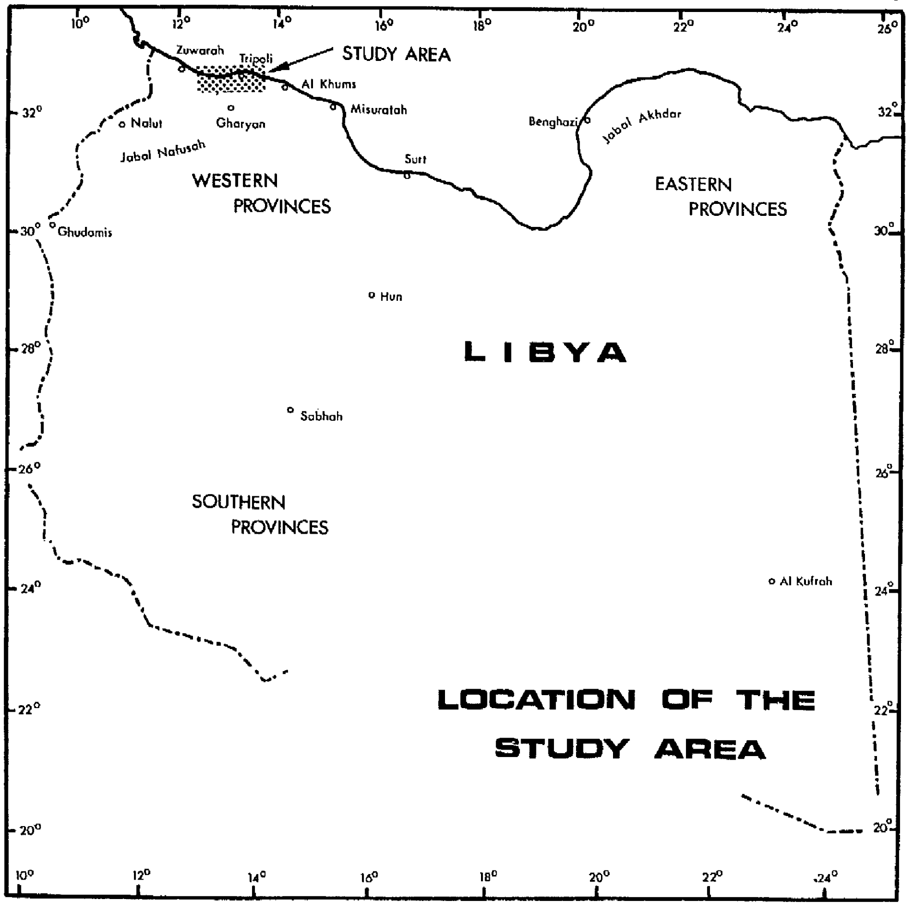
* This study deals with the period to the end of 1968, and takes no account of changes resulting from the constitutional developments following the events of 1st September, 1969.

FIG 1.1


STUDY AREA
Zuwarah
Tripoli
Al Khums
Misuratah
Nalut
Gharyan
Jabal Nafusah
Benghazi
Jabal Akhdar
Surt
WESTERN PROVINCES
EASTERN PROVINCES
Ghudamis
Hun
LIBYA
Sabhah
SOUTHERN PROVINCES
Al Kufrah
LOCATION OF THE STUDY AREA

1.2 Statements to be Tested in the Study

Six statements will be tested and these will be examined in chapters 5 and 6. It has been possible to summarise the major changes in agriculture in the study area in the first three statements, 1.1, 1.2 and 1.3 below.

1.1 Agriculture was developing and intensifying on ex-colonist farms, but not on traditional farms.*

1.2 Irrigated agriculture was being extended.

1.3 The former 'parallel'** arrangement of agriculture was no longer so clearly defined, as a result of ownership changes (colonist farms having been acquired by local Libyan farmers), mechanisation of both types of farm, and the extension of traditional methods to ex-colonist farms.

In the discussion of these propositions in chapter 5, it has been possible to present a clear exposition of the trends in agriculture in the study area. Both the types of farm being most affected by change and the specific areas involved in development will come to light, as well as any general systematic or regional patterns.

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* This definition of 'traditional' and 'ex-colonist farms' is basic to the organisation of the thesis. The two types of farm will also be referred to as 'type 1' and 'type 2' farms from time to time. The validity of the classification and the modification to which it was being subjected will be established in Chapter 5, section 5.3

** As defined by Janet D. Henshall in 'Models of agricultural activity', (Models in Geography - Chorley & Haggett, 1967. p. 435.) 'Parallel' means two separate types of agriculture run by separate groups, formerly the traditional Libyan contrasting with the modern Italian farms.

In the second group of statements, which will be discussed in chapter 6, constraints on development, as evidenced by field and other data, will be identified and discussed. The statements are as follows:-

2.1 Water resources were insufficient to support the further extension and intensification of irrigation at the 1960-68 rate. These resources have been dangerously depleted.

2.2 Agricultural wage rates were increasing rapidly, making profitable farming extremely difficult.

2.3 Government support in the form of loans and subsidies were important to maintain agricultural development.

It will become clear that the most important constraint on long term agricultural development was that of poor underground water resources, but other economic pressures, especially those associated with rising wages and the availability of sources of investment will be shown to have more significance in the short term.

CHAPTER 2.

DEFINITION OF THE TOTAL STUDY AREA, ITS RECENT AGRICULTURAL HISTORY AND ECONOMIC BACKGROUND

2.1 Definition of the Study Area

The total study area forms a triangle of productive agricultural land, to the west, east and south of Tripoli. It comprises 1402 square kilometres approximately of farmland (140,200 hectares) of which about 25% is normally not used for agriculture, in that farming is discontinuous, with areas of waste land between areas used for crops.

Figure 2.1.1 shows both the total study area, its location in the Western Provinces of Libya, and also the extent of the areas of detailed study, namely Talbighah and Suwani bin Yadim.* Figure 2.1.1 also shows that the total study area lies in two muhafadat (i.e. main administrative areas), those of Zawiyah and Tripoli, It forms a triangle, bounded by the coast of the Mediterranean in the north, with its western extremity marked roughly by the settlement of Ajaylat, and its southern by that of Aziziyah. (See Symap, Fig 3.2). Other major settlements are shown on the computer maps, referred to as symaps. (See Appendix 1 for further explanation of the symap programme) The locations of the 184 sample farms in the Tripoli triangle are also shown on Figure 2.1.1 sampled during the Joint Universities Survey of 1968. Traditional farms and ex-colonist modern farms are also indicated on Figure 2.1.1.

The descriptions 'traditional', and 'modern' have been used to distinguish the 'traditional' irrigated gardens ('saniya') from the 'modern' farms, which were set up by Italian colonists between 1911 and 1939, or subsequently by other agencies and Libyan farmers. The

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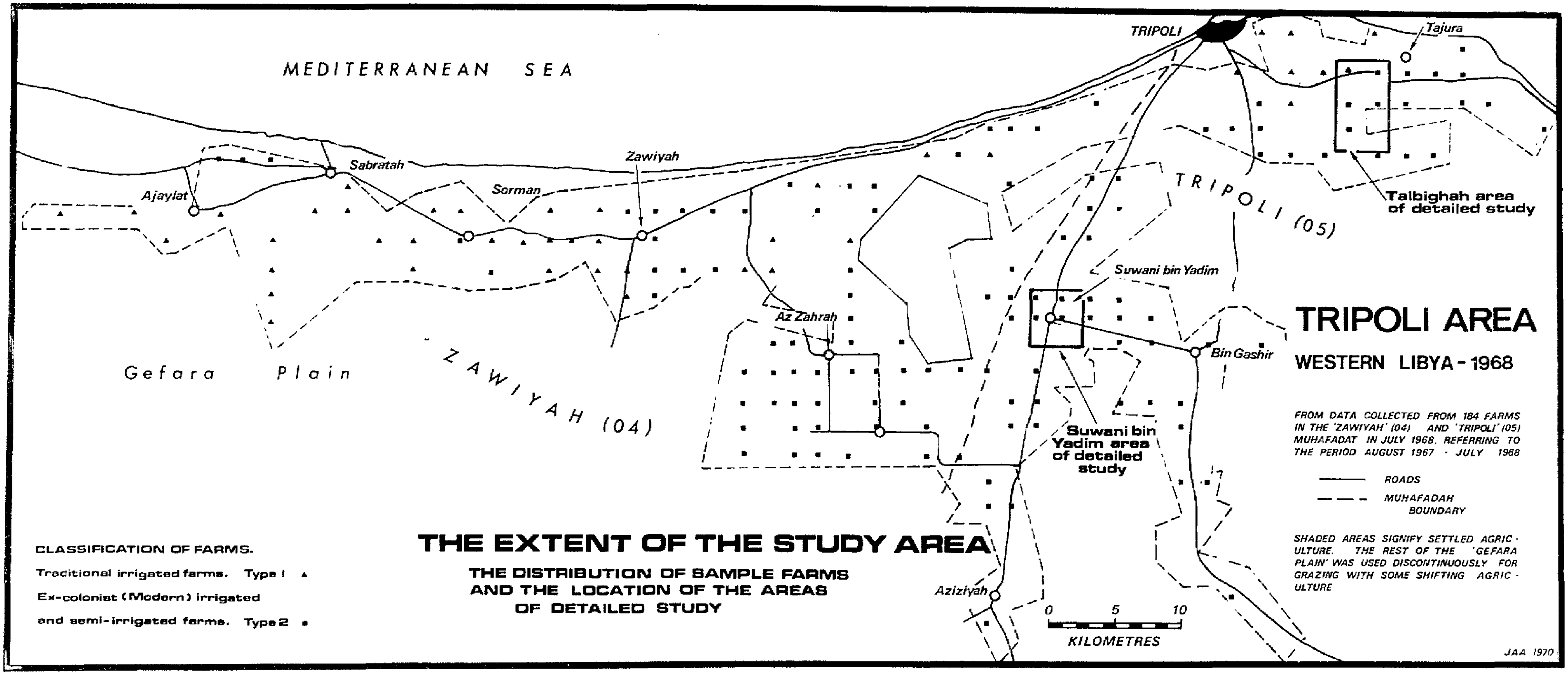
* The term 'total study area' will be used to distinguish the whole area under review, from the two areas of detailed study (Talbighah and Suwani bin Yadim) which will be referred to as 'case study areas', or 'areas of detailed study'. The total study area will sometimes be referred to as the Tripoli triangle.



MEDITERRANEAN SEA
TRIPOLI
Tajura
Talbighah area of detailed study
TRIPOLI (05)
Suwani bin Yadim
Bin Gashir
Suwani bin Yadim area of detailed study
Az Zahrah
Aziziyah
Zawiyah
Sorman
Sabratah
Ajaylat
Gefara Plain
ZAWIYAH (04)
0 5 10
KILOMETRES
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND 'TRIPOLI' (05) MUHAFADAT IN JULY 1968, REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE. THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
THE EXTENT OF THE STUDY AREA
THE DISTRIBUTION OF SAMPLE FARMS AND THE LOCATION OF THE AREAS OF DETAILED STUDY
CLASSIFICATION OF FARMS.
Traditional irrigated farms. Type I ▲
Ex-colonist (Modern) irrigated and semi-irrigated farms. Type 2 ■
JAA 1970

FIG 2.1.1

traditional farms near the coast have been farmed usually since before the Italian colonial period, and until recently by traditional methods, characterised by the 'dalu' well and the 'gedula'* method of irrigation. The modern irrigated and semi-irrigated farms which date from the Italian colonial period are found further inland.

The 184 sampled farms were part of the sample of 371 farms visited in connection with fieldwork for the Libyan University-London University Joint Research Project carried out in the Western Provinces of Libya in July 1968. This was a systematic sample, that is farms were selected on a two kilometre grid. 219 locations were originally selected in the 'Tripoli triangle', but of these 23 were found to be unused, and no longer of agricultural importance, for example they had been built over if near Tripoli, or sometimes on large farms more than one sample point fell on the same farm. In addition data from 12 farms were found to be unsatisfactory after checking, and this material was rejected.

From the data from the 184 sample points the computer maps have been prepared to indicate the main characteristics of agriculture in the total study area.

The edge of the total study area, that is the limit of the farmed area, was fixed by means of field visits. It has been slightly conventionalised on the symaps as the standard line printer of the computer prints symbols $\frac{1}{8}$" x 1/10", a size too large to show detail precisely. This computer graphic display of the data has proved an excellent as well as quick method of illustrating a number of farm characteristics. The maps are of the 'isarithim' or 'contour'

* Local method of levelling land, and arranging low earth banks around small rectangular plots, sometimes only four square metres in extent, to control irrigation water.

type, which means that interpolation has been carried out between the sample points, and an appropriate shading range devised to show various levels of activity throughout the study area.

Three maps (numbers 3.7, 3.20 and 3.21) are of the 'proximal' type. In these cases interpolation between sample points has not been carried out, and appropriate symbols are printed for a limited area around each sample point.

2.2 Recent Agricultural History

For three millenia coastal Western Libya has suffered invasions from the north and east. Relica of the urban and agricultural activity associated with the earliest of these occupations in classical times, indicate that irrigated agriculture, dry farming and wadi control were carried out more extensively than at present by Phoenician and Roman farms.

The Arab advances of the seventh century brought a strong nomadic influence and emphasised grazing in the agricultural economy. The indigenous Berber population was pushed to the west or took refuge on the hills of the Jabal Nafusah. This pattern was reinforced by the powerful incursion in the eleventh century by nomadic tribes (Bani Hilal, Bani Suleim), tribes originally from the Arabian Peninsula, which had settled for some years in Egypt.

2.2.1 Traditional Libyan Farming

1. Dry farming

The possibilities for, and restrictions upon dry farming will be outlined in the section on crop ecology (4.1.4). At this stage it is sufficient to say that the unreliability of rainfall brings a fluctuation in the area successfully cropped from year to year, while a reference to Appendix 2.6 will confirm that the study area may in some years have insufficient rain during the winter rainy season to support any crops. The whole of the study area south from the coastal oases was used intermittently for traditional dry farming before 1911 ; these dry southern margins being used by farmers from the oases for dry land grain crops as rains permitted. The Suwani bin Yadim area for example was inhabited by semi-nomadic people, until the later part of the nineteenth century when a number of families arrived from the Eastern Provinces to settle in the area and gave their name to it, namely Bin Yadim (ben Adem). There were no permanent dwellings there in 1911, and agriculture was mainly of the unreliable dry land type.[1]

In few areas was there any element of shifting agriculture in 1968. There were, however, a number of farmers who still used traditional methods, that is unmechanised ploughing, broadcast sowing, and hand reaping, sometimes in areas where Italian farmers had previously used more advanced techniques.

2. Traditional irrigated farming

The northern part of the study area was typical of many areas of traditional irrigated Libyan farming in coastal Libya. Irrigation was from wells, originally of the 'dalu' type (skin-bucket raised by animal power), with tree and field crops grown together very intensively. Farming practices were little changed, although by 1968 the water was generally raised by electric pumps. Field crops were grown in small levelled rectangles, approximately four metres square (gedula), beneath tree crops such as the olive, plum and apricot, which in turn stood beneath a canopy of date palms.

This pattern existed throughout Turkish, (Second Turkish administration 1835-1911) and remained unchanged during the Italian occupation after 1911, and was essentially the same in 1968, except that since 1963 there had been a progressive decline in the intensity of land utilisation and an increase in housing density (see Chapter 6). The farm size was small, averaging less than two hectares, ranging from one quarter of a hectare to above two hedtares. The small size reflects subdivision of the farms through inheritance, and there was some evidence that one farmer might own a number of separated parcels,[2] although this was less important in Talbighah than in some other similar areas as described by Theodorou.[3]

Intensive traditional agriculture has been confined to coastal areas and has never been undertaken on a large scale at Suwani bin Yadim, which lies 20 kilometres from the coast. Before 1911, however, one environmental factor was different, especially at Suwani bin Yadim. Underground water levels were higher and there were some surface pools.[4] In other words the water table was very close to the surface. Very shallow wells were sufficient to reach this water, and at Suwani bin Yadim for example there were small areas of traditional 'garden' farming, giving the area the first part of its name, Suwani (Suani), the word used by Libyans to describe their intensive irrigated gardens. This traditional irrigated farming was completely overshadowed after the arrival of the Italians in 1911, whose demands for labour were high on the large new farms. Since their arrival there has been very little traditional Libyan intensive irrigated farming in Suwani bin Yadim.

2.2.2 The Turkish period

I have been able to find very little field or documentary evidence for the limits and characteristics of the last period of the Turkish administration which ended in 1912.

There is one ruined Turkish fort in the east of Talbighah, only half a kilometre south of the main road which runs through the case study area from west to east. The fort could have had some military function, standing as it did close to the main east-west route.

A map reproduced in fig. 2.2.1 shows the extent of irrigated cultivation in one of the case study areas in the Turkish period. The map shows the position in the late nineteenth century, being taken from an Italian 1:50,000 reproduction[5] of a Turkish map originally published at 1:25,000. Unfortunately the original map was insufficiently controlled, and important items of detail do not fit the 1:50,000 A.M.S. maps used along with fieldwork to establish the position in 1968. However, the old map is sufficient to indicate that there had been little change in the limit of traditional irrigated agriculture since the nineteenth century. Irrigation had been considerably extended, however, by the large Italian concession owners, S.A.C.I.A., and also on the smaller private concessions further south.

2.2.3 The Italian period 1911-1942

Although the period of Italian influence extended from 1911 to 1942, there were Italian subjects in Libya before this date, and the alleged 'danger' to which they were exposed by the movement of troops and arms from Constantinople to Tripoli, was one of the reasons for the declaration of war by Italy upon Turkey in 1911.[6] Significant changes in agriculture resulting from the Italian presence did not take place, however, until after 1912.

The study area was that most affected in all of Libya by Italian development, and it was here that Italian agricultural reorganisation first commenced. Both Talbighah and Suwani bin Yadim were readily accessible from Tripoli,* and in both groundwater was

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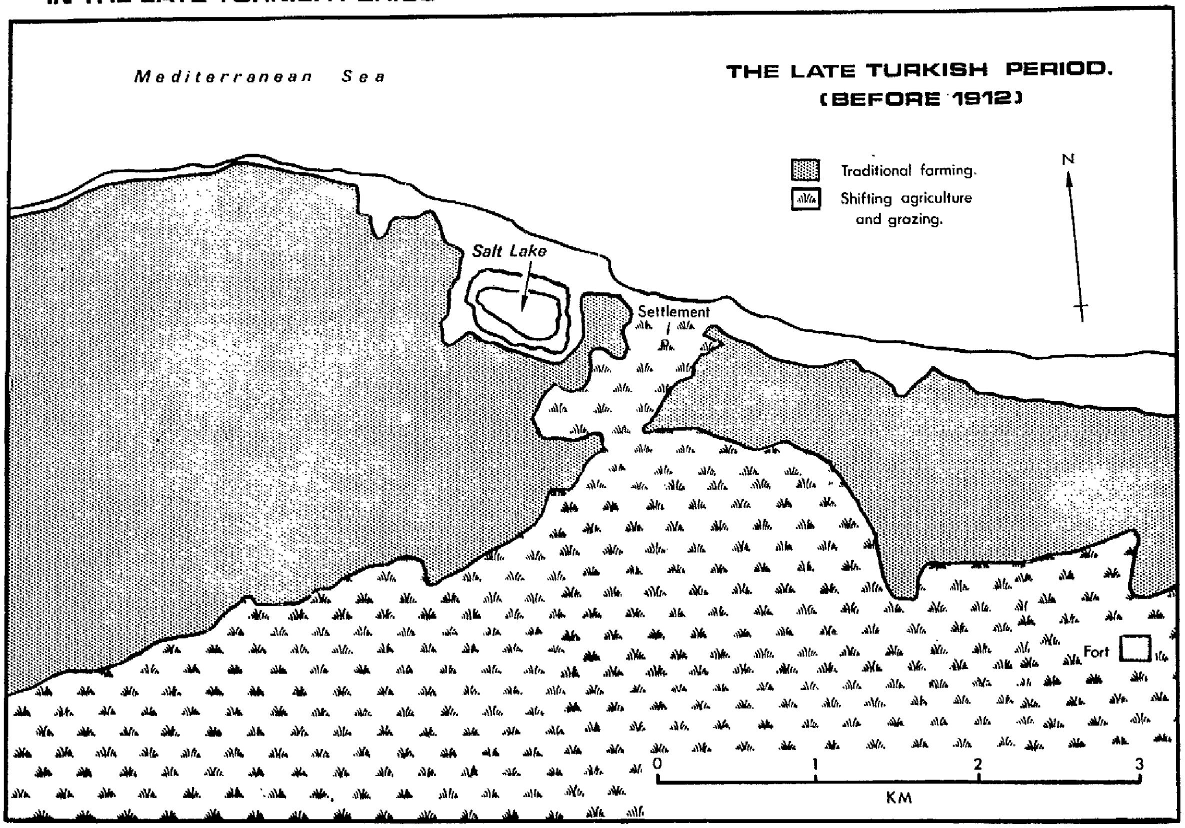
* A railway was built in the south in 1912, and the railway station was the first building in Suwani bin Yadim, around which the settlement grew over the next 20 years.

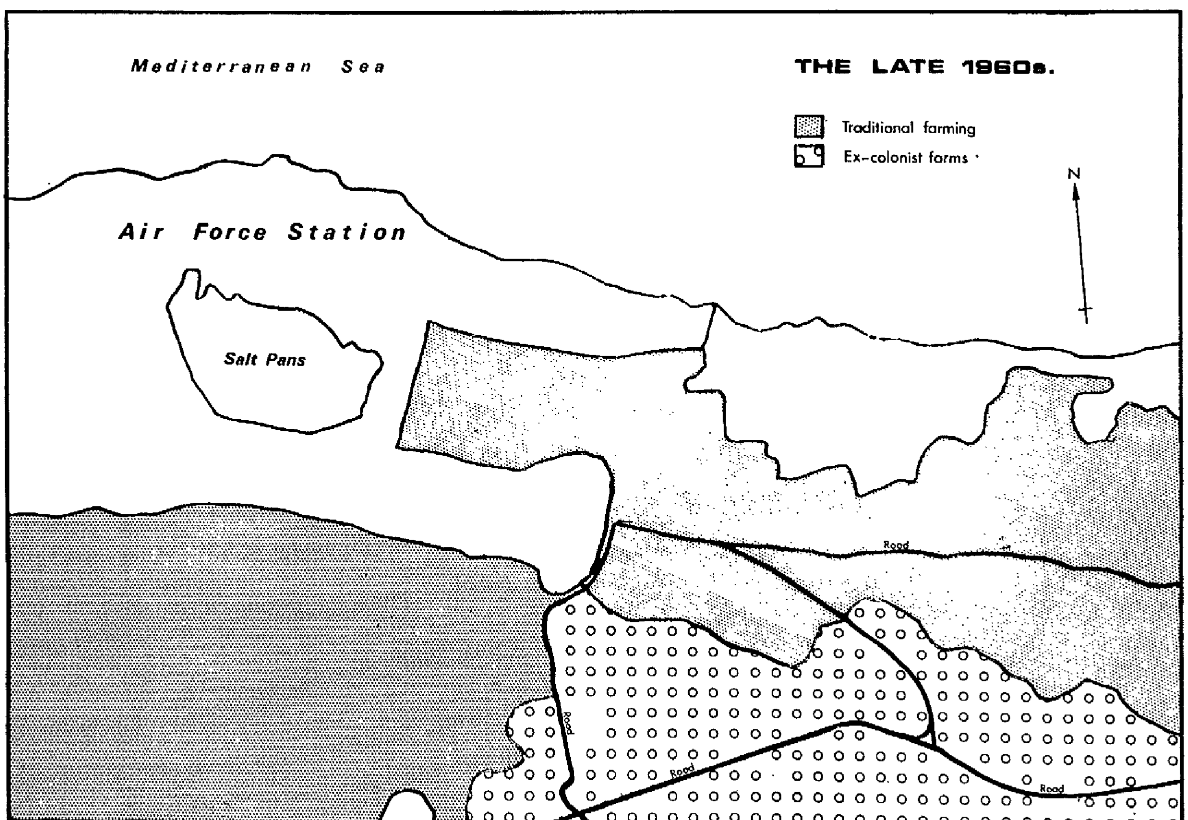
Fig 2.2.1

MELLAHAH

THE EXTENT OF TRADITIONAL IRRIGATED AGRICULTURE IN THE LATE TURKISH PERIOD & IN THE LATE 1960s.



Source: Turkish map reproduced by the Italian-Istituto Geogratico Militare.(Scale 1:25,000).



Source: USAMS Series P761, Sheet 1990 land Fieldwork available. Water was only six metres below the surface in the Talbighah gardens, and could be presumed to have been only a little lower in the area to the south. At Suwani bin Yadim water stood in the surface during the winter season, and duck could be shot there.[7]

During the period of Italian agricultural development olives were planted on most of the southern part of the Talbighah area, except in the dunes in the extreme south ; while at Suwani bin Yadim almonds and olives were planted over most of the area, there being exceptions where it was decided to grow vines or citrus.

Inter-cropping with grain and other dry crops was planned, and as irrigation works developed, new areas were brought under irrigation. Between three and four kilometres of underground pipe were laid on the S.A.C.I.A. concession in Talbighah, and by the end of the 1930s the spray method of irrigation was being used throughout the area.

The Italian authorities were however aware that areas further from the coast had limited underground water, and large areas of the Gefara were designated as areas of dry farming. It seems very likely that the Suwani bin Yadim area was such an area.

Air photos show clearly how influential was the period of Italian rule in changing the agricultural landscape (Fig. 2.2.2 and 2.2.3). Their large farms contrast strongly with the Libyan gardens as well as with the still unused dry area. The largest concessions in the field areas were over 500 hectares, prior to disposal as smaller units in the years since independence. Concessions of 1000 to 2000 hectares were not uncommon in places ten kilometres distant from the Talbighah area. Most of the private Italian farms were between twenty and fifty hectares however.

Detailed fieldwork has shown that the Italian presence was still important in 1968. Between thirty and thirty five per cent of the Talbighah area was still Italian owned and run, while at Suwani bin Yadim

TALBIGHAH **1953** **FIG 2.2.2**

Fairey Surveys Ltd. April 1953

1968

Aero Exploration February 1968

Approximate scale
1:25,000

SUWANI BIN YADIM

FIG 2.2.3

1953

Fairey Surveys Ltd.

June 1953

1968

Hunting Surveys Ltd

June 1968

Approximate scale
1:25,000

the proportion was between twenty and twenty-five per cent. These figures compare with 85% Italian ownership in 1939 in Talbighah and 95% in Suwani bin Yadim. That so many Italian farmers remained reflected the wish of the former British Military Administration (1942-51) and the regime of the former King Idris (1951-1969) to retain the farming skill of the ex-colonist farmers.

2.2.4 The British Military Administration

Little advance was made during the British period of "care and maintenance" (1942-1951). For some years before 1951[8] it was believed that the Italian government would resume the administration of "Tripolitania", and Italian farmers were encouraged to stay on their farms.

Investment was certainly less during this decade than during the Italian period, and very few extensions of the areas farmed were made, and there were certainly no new developments in the areas of detailed study.

2.2.5 Agriculture since independence

December 1951 brought independence for a united Libya. This event affected agriculture in two ways. First a number of Italian farmers left the country, despite very reasonable arrangements concerning Libyan nationality and farm ownership. Second rather more investment funds became available from U.S. and U.N. sources. Public investment in agriculture and irrigation rarely rose above £300,000 per year for all of Libya before 1951, while after 1952 it climbed from £300,000 to £1.9 mn. by 1955/56 and to £2.6 mn. the year before the oil revenues could make any significant impression upon Libya investment at home. These figures reflect programmes of technical assistance mounted by the United Nations agencies and the United States.

These investments, however, made little change in the two field areas, as the aid programmes were directed to other specific areas, such as Wadi Ki'am (Caam), further to the east. Also the departure of Italian farmers did not occur in the areas of detailed study until after the oil revenues were available after 1961.

The records made by Cederstrom between 1957 and 1959 when measuring underground water levels in both Talbighah and Suwani bin Yadim show that most farms were still Italian run up to 1960. Cederstrom's records do not cover all farms, but his reasonably comprehensive cover indicates that more than 70% of farms in both case study areas were still Italian owned.

It was not until the government possessed resources to allocate to agriculture after 1961 that the pattern of Libyan ownership took its present form in the study area. Loans to purchase land were possible, and it is significant that the long term loans were granted by the Agricultural Bank, between 1960/61 and 1963/64, and not subsequently. (APPENDIX 13.1)

At the same time individuals who had accumulated money from work connected with the new oil industry were able to set aside capital for the purchase of land. For example clerks in an oil company office,[9] or a small scale transport contractor[10] could find the £L 200 per hectare required to purchase their farms of six and nineteen hectares respectively in the early 1960s. The latter was able to obtain further loans and subsidies to assist him with his citrus and poultry developments. At the same time their investment in land had increased in value, as a result of a five fold increase in land values, in less than five years (1963-1968).

2.3 The Broad Impact of Oil Revenues on the National Economy

2.3.1 Oil Revenues and the Role of Government in Agricultural Development

Petroleum exports commenced in 1961 and oil revenues have risen rapidly from £L 14 mn. in 1962 to over £L 270 mn. in 1969.[11] The 1963-1968 five year development plan budgeted to spend some £L 29 mn. on agricultural development out of £L 169 mn., the estimated total development budget. Since a total of over £L 300 mn. and not £L 169 mn. were spent on development in the five years, because state revenues were higher than expected, & £L 38 mn. were spent on agriculture from the development budget.

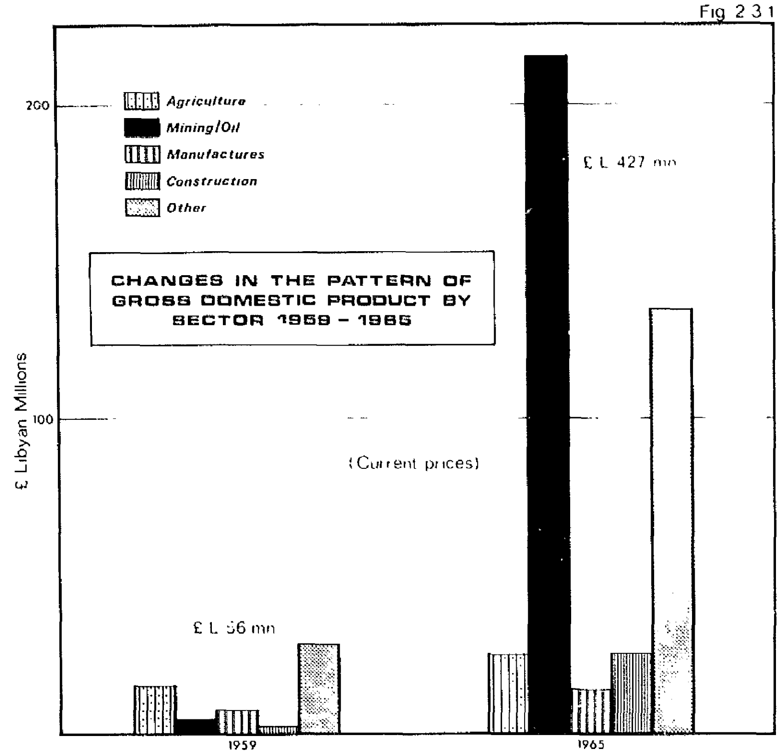
Until 1969 Libya allocated 70% of its revenues to development by law, and the Ministry of Development and Planning was charged with the responsibility of coordinating national investment and development.

The change which has taken place since 1961 in the make up of Libya's gross domestic product can be seen in Figure 2.3.1. Before oil agriculture was the major sector. By 1965, mining, including oil, had overtaken the agricultural sector, while 'other activities', (which include commerce, marketing and transport) and the construction sector had grown much more rapidly than agriculture. At the same time per capita income had risen from amongst the lowest in Africa at £L 15 - £L 20 per head in 1959 to an average of £L 104 in 1964.[12] Regional figures showed Suq al Jumah to have £L 103 per head per annum, in 1964 ; Suq al Jumah being the administrative area in which were located both of the areas of detailed study, Talbighah and Suwani bin Yadim at the time of the study. Further increases in oil revenues brought the per capita income to £L 325 by 1968.

2.3.2 Imports of Food Products

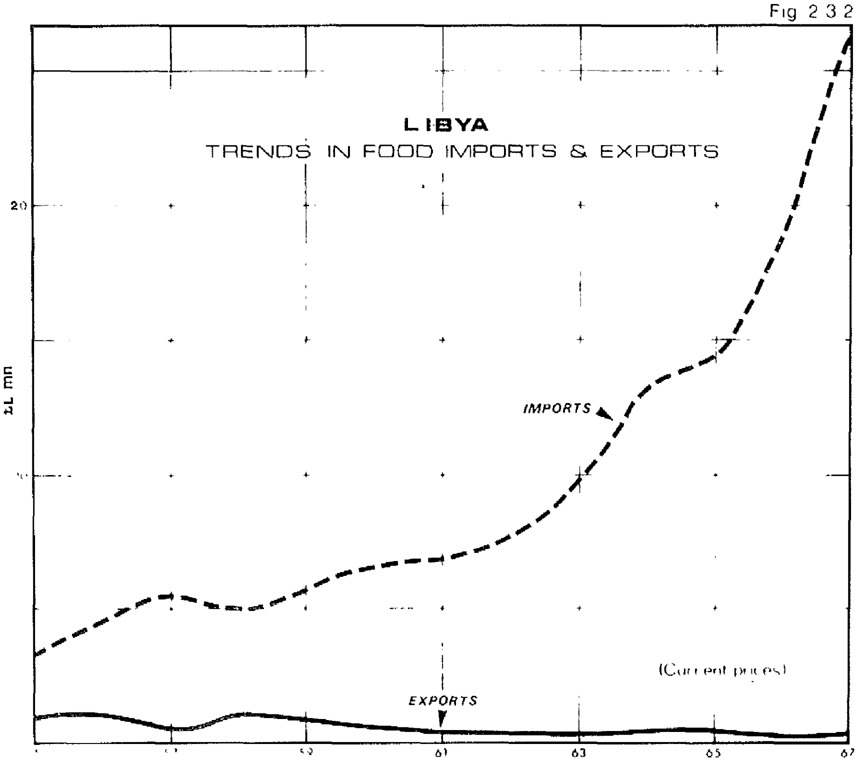
Figure 2.3.2 shows the pattern of food imports and exports. Exports have tailed off, indicating partly increased home consumption as well as an absence of the need to export. The massive increase in

Fig 2.3.1



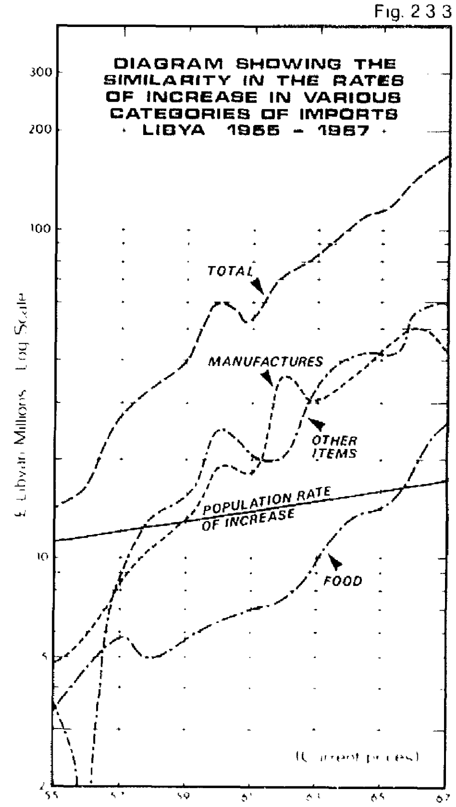
Source Census and Statistical Department, Ministry of Economy and Trade, STATISTICAL ABSTRACT, 1964 & 1965, and GNP REPORT, July 1967.

Fig 2.3.2



Source (Figs 2.3.2 & 2.3.3) Ministry of Economy and Trade, EXTERNAL TRADE STATISTICS 1955-67.

Fig. 2.3.3



food exports was running at a rate of 15% per year between 1963 and 1968. This rate of increase cannot continue but the figures indicate that by 1972 Libya might be importing 75% of its food, whereas in 1959 it produced 75% of its food needs.

There has been, therefore, a growing market to be satisfied, and this was an important part of the background to Libyan agriculture in 1968. These considerations are important in chapter 5, where an attempt is made to assess agricultural outputs, and it is concluded that outputs are rising, but very slowly.

2.3.3 Rising Wages and Prices

Data are not complete in respect of price indices ; however, it is fortunate that figures for the 'Food Group' go back to 1955. From this set of indices, set out in full in Appendix 11 it can be seen that from the base of 100 in January 1955 the index has moved to over 200 by the end of 1968.

This increase in prices is much exceeded by the increase in agricultural wages, which have increased sixfold between 1953 and 1968,[13] and even during the three years of my fieldwork in Libya, agricultural wages have doubled. (1965-68) (See APPENDIX 12).

This question of increasing wages and food prices will be examined in Chapter 6, where it is concluded that the price of Libyan agricultural labour had reached by 1968 a point where it is not possible for farmers to employ sufficient farm workers at a cost consistent with an economic return from the farm enterprise.

2.3.4 Farm Investment

The change in the pattern and volume of investment in agriculture has been touched upon in the preceding section, 2.2.5, where it was shown that the source of the investment funds has become national oil revenues, rather than a number of international agencies. There has been in addition a sharp increase in investment, and at first this investment was in the purchase of land.

Evidence from air photographs shows clearly that especially between 1965 and 1968 in the field areas, there has been a considerable expansion in rural housing, and in one area, analysed carefully, the number of houses increased by 50% in this three year period, with an overall doubling in the number of houses since the pre-oil years (See Figure 2.3.4)

The Joint Universities' questionnaire surveys show that in the 1967/68 period the trend was possibly away from housing, and a higher proportion of investment was going on tractors, irrigation equipment and transport. The amount invested per farm on such items varied greatly especially between 'traditional' and 'modern' farms, but would appear to be about £L 12 per hectare for the Western Provinces.[14] More detailed work in the case study areas of Talbighah and Suwani bin Yadim indicate that rather more was being spent on farm equipment, with the 1967/68 investment running at £L 15 per hectare.[15]

In the areas of detailed study no farmer of those sampled had had financial assistance in the recent past, and it would seem that only a small part of the £L 1 mn. to £L 2 mn. per year allocated by the agricultural bank came to these areas. Government assistance was available, however, to those rearing livestock. Feed subsidies of 50% of the cost of feed were available. This was especially important to the one large poultry farmer in the area; the subsidy turned a potential loss into an equivalent profit.

The trends in investment will be analysed in Chapter 6, where it is concluded that successful investment of which there is one very encouraging example in the Talbighah area, must be associated with

HOUSING BEFORE & AFTER OIL Fig 2.3.4

TALBIGHAH

Source: *Fairey Surveys, print 3030*
Aero Exploration print O77

skilled management and appropriately motivated labour.

2.3.5 <u>Constant Features of the Libyan Economy</u>

One charateristic which has remained unchanged throughout the period of the British Military Administration (B.M.A.), and subsequently,** is the growth of population. Official census returns showed the increase to be in the order of 3.7% per year between 1954 and 1964.[16 & 17] Earlier estimates for 1946 made by the B.M.A. indicate that the population was 803,915 (including 28,000 Jews, who mainly left Libya in 1947/48, and 40,000 Italians, of whom 14,000 left before the period of the study, and the rest after July 1970).

TABLE 2.3.1.

Population of the Western Provinces of Libya

	1946	1954	1964
Citizens	732,591*	694,685	1,034,000
Aliens			
Italians	40,536*	37,655	20,616
Other	30,788*	5,992	16,500

Sources : 1946 B.M.A. Estimates - Appx I. Handbook on Tripolitania 1947. & [illegible] Tripoli 1955 & 1966.

Notes * The accuracy of the 1946 data is in doubt. It would also appear that the 1954 data may be underestimates.

The definitions in 1946 were slightly different from those for 1954 and 1964. The B.M.A. Handbook lists 'Moslems', 'Italians' and 'Others'. The later censuses show 'Citizens' and 'Aliens'.

There is therefore a very high and continuing rate of population increase in excess of three per cent per annum, which will

** Dr K. S. McLachlan showed in his Ph.D. Thesis, Durham 1961, that the beginning of rapid population expansion can be traced to the Italian period.

maintain the youthful balance of the population (50% under 20), and present difficulties for educational and related training services. More important the growth in population will more than absorb any increases in agricultural output. It is shown in Chapter 6 quoting CLARK[18] that increases of agricultural production in excess of 2.5% per year are unusual, which is lower than Libya's rate of population increase.

Another constant feature in the Libyan scene is the urbanisation of its population. A recent survey[19] showed that 48% of the families of Tripoli had come from outside Tripoli. Unfortunately there are no reliable data giving the exact rate of increase in urban population or the corresponding depopulation of rural areas.

2.3.6 Part Time Farming

Possibly the most important effect of the increased wealth of the country upon agriculture is the change in the pattern of employment. The oil industry employed very few people in 1968--about 10,000. The government was the main employer of wage labour. The army, police and civil service absorbed up to 30% of the labour force and through the wages paid to these state and other employees the oil wealth had been effectively distributed to the Libyan people. At the same time it had led to an unfortunate trend towards part time farming.

Opportunities for urban and other government wage employment had been taken up by 25% of farmers in for example Talbighah and Suwani bin Yadim. Tripoli could be reached from both areas within half an hour, and so relatively few people had moved their homes to Tripoli, despite many being employed there.

The important advantage to agriculture from this seeking of paid employment in the town (where the average family earned £L 90 per month[20] (1969)), was that money could be set aside to invest in the farm. This aspect is treated in Chapter 5.

CHAPTER 3.

DESCRIPTION OF AGRICULTURE IN THE STUDY AREA

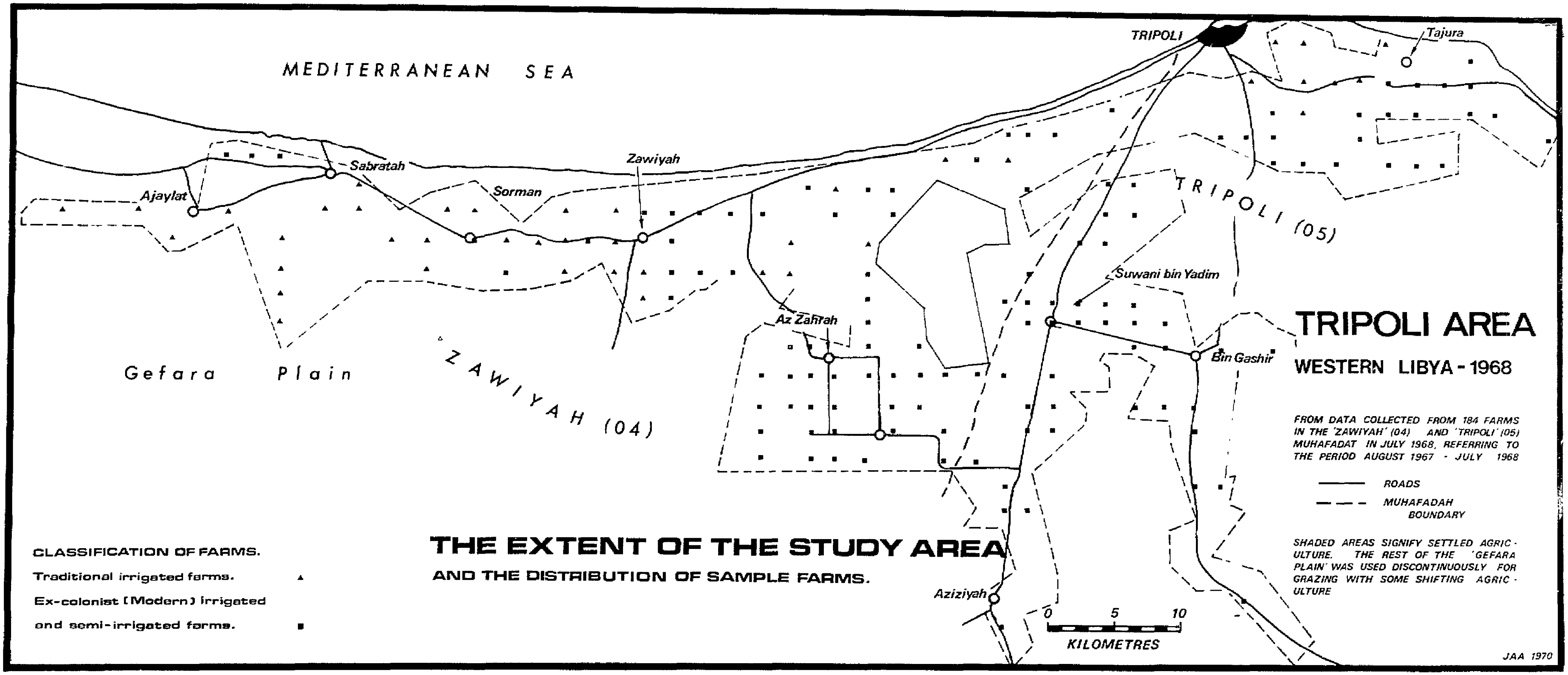
3.1 Farm size and fragmentation

In Figure 3.2 the relationship between farm size and farm type is clearly demonstrated. The traditional farms which lay generally to the north of the main east-west highway are shown to be smaller than the modern farms to the south. Farms under five hectares rated as small farms, and the disposition of such farms is shown on the symap (Fig.3.2) The analysis of traditional farms throughout the Western Provinces showed their average size to be 4.0 hectares, which compared with an average size of 31.3 hectares for farms of the irrigated or semi-irrigated modern type. The last high average size arose partly from the presence of a number of very large farms, such as the two farms of more than 3000 hectares which lay in the Tripoli triangle, one at Aziziyah in the south, and the other in the extreme north east corner of the study area (Fig.3.2).

Farms were also generally small when located near settlements. Aziziyah has been mentioned as an exception, and Zawiyah was the only other, where a large modern farm lay just to the east of the town.

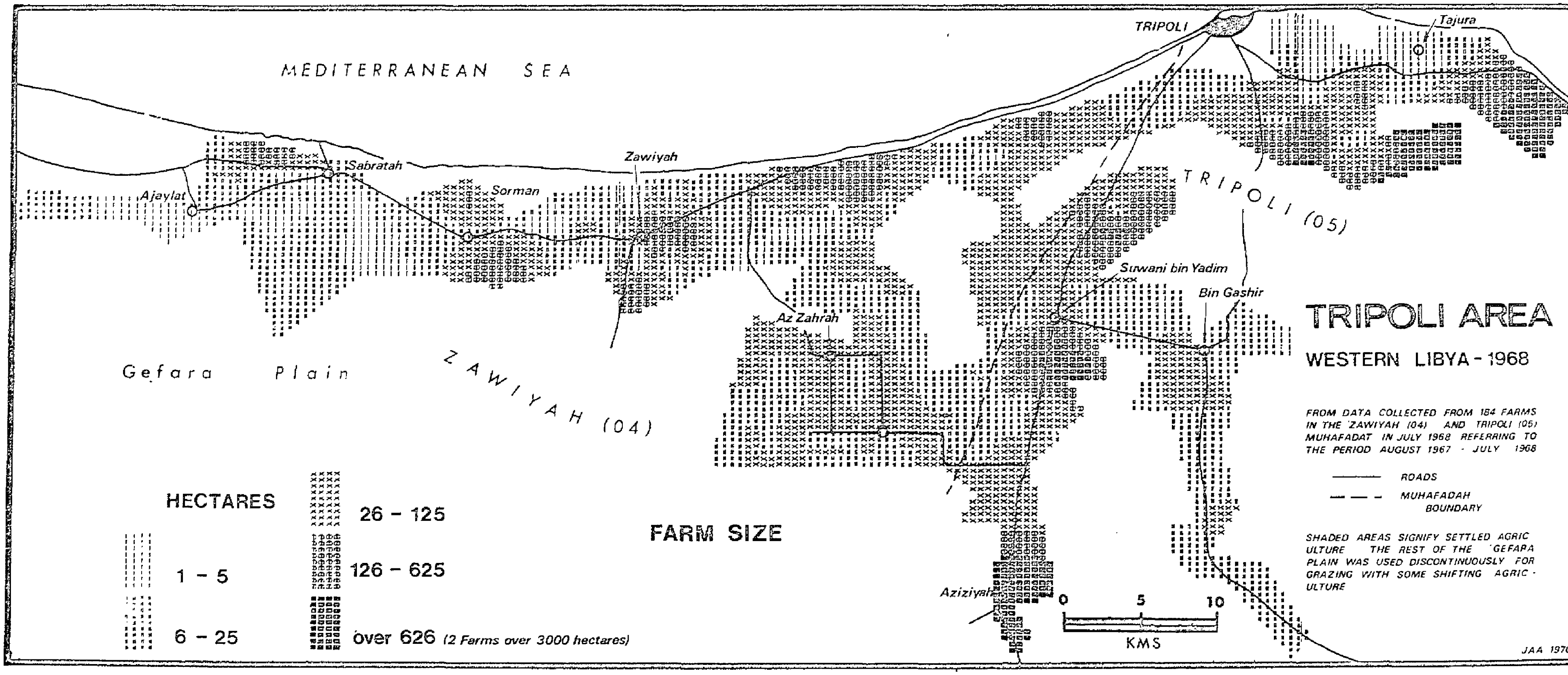
Small farms also predominated to the west and south west of Sabratah, as this area was unaffected by Italian colonisation to any significant extent. Not so the area around Az Zahrah which was shown to have farms consistently over 5 hectares, and the majority 25 hectares or more in area. This was a region laid out for Italian demographic settlement with holdings of 25 and 50 hectares, which had subsequently been subdivided by purchase, and in some cases amalgamated.

Such consolidation is not characteristic in Libya as the subdivision of holdings by inheritance is the rule, and traditional farms in some parts of the Western Provinces, especially in the dry



THE EXTENT OF THE STUDY AREA AND THE DISTRIBUTION OF SAMPLE FARMS.

FIG 3.1



MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Ajaylat
Zawiyah
Sorman
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
HECTARES
1 - 5
6 - 25
26 - 125
126 - 625
over 626 (2 Farms over 3000 hectares)
FARM SIZE
0
5
10
KMS
JAA 1970

FIG 3.2

hill areas, had upwards of five parcels per farm (see Fig.3.3). Joint research project data for irrigated traditional farms indicated the average number of parcels per farm to be 1.3, scarcely different from the 1.4 parcels per farm for irrigated and semi-irrigated modern farms. It was also shown that 44% of traditional farms had more than one parcel, compared with 28% of the modern farms.

Fragmentation proved difficult to map (Fig.3.3) and further fieldwork indicated some of the reasons. One was that farmers from the traditional farms north of the main east-west highway had often purchased part of a large modern farm further to the south. Such a pattern was found to the east of Tripoli, and in the settlements around Zawiyah. Thus a higher number of parcels has been attributed to sample farms from the 'modern' than from the 'traditional' sector, since residence had often been taken up on the new farm, especially if it included an ex-colonist's house. In addition the systematic method of sampling, with the same grid for the small traditional and the large modern farms, has led to a less representative sample of traditional farms being considered than modern. Thus it is possible that the degree of fragmentation of traditional farms is not properly shown. Certainly Theodoru[1] collecting information in 1953 in the Zawiyah area showed that it was possible for traditional farmers to hold up to 17 parcels in this region. The 1960 agricultural census, interpreted by Azonni and Attiga,[2] showed that the average holding in Western Libya included nine parcels, ranging from one to 44 parcels. Clearly such extremes were not found during the fieldwork of the Joint Research Project, and those conducting the survey found it difficult to confirm the findings of the 1960 agricultural census.

Another feature of fragmentation revealed in Figure 3.3 is the high level of fragmentation of farms located near the major

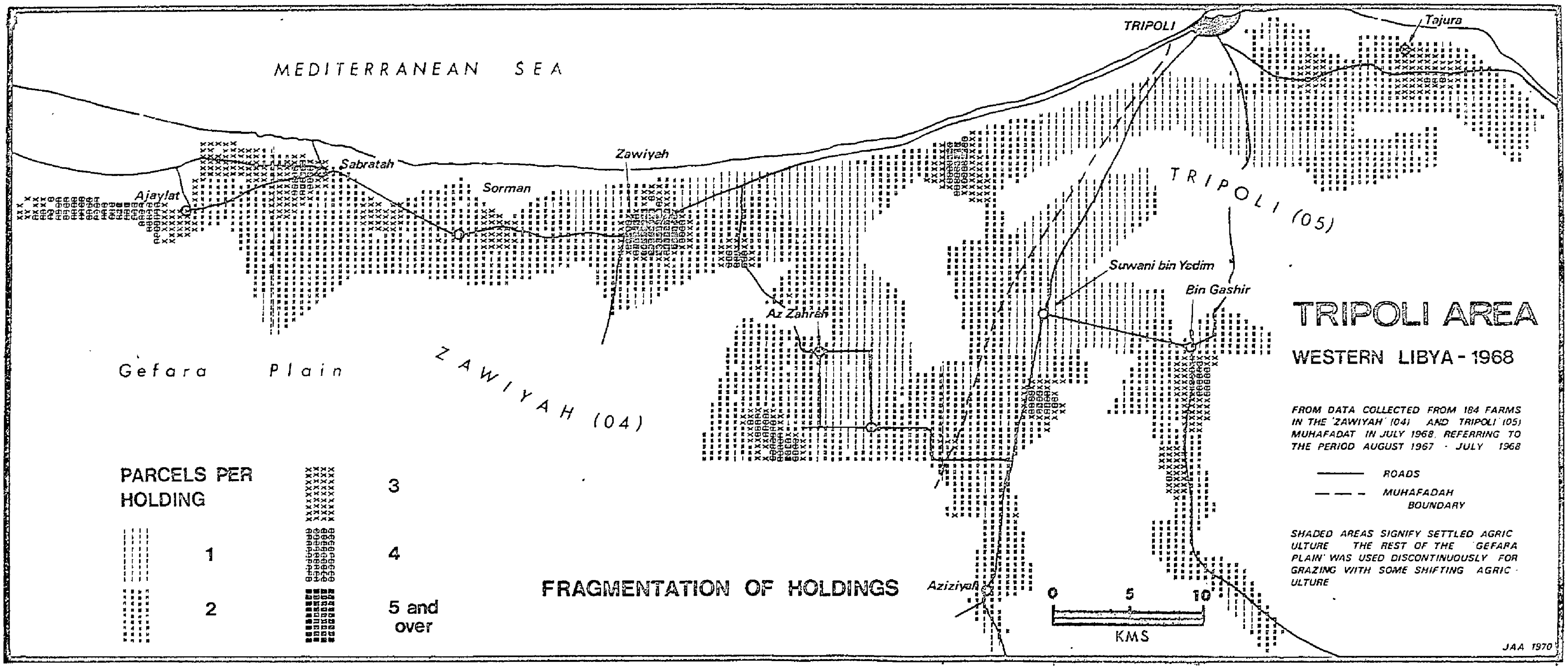

MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Ajaylat
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968, REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
PARCELS PER HOLDING
1
2
3
4
5 and over
FRAGMENTATION OF HOLDINGS
0
5
10
KMS
JAA 1970

FIG 3.3

settlements. It is the area around Zawiyah which, as Theodoru indicated, had the most highly fragmented farms. 1968 data showed these to be an average of five parcels per farm. This was extreme for the 'Tripoli triangle', although farms near other settlements, such as Ajaylat, Zanzur (between Zawiyah and Tripoli) and Bin Gashir, also showed high fragmentation with four parcels per farm. Lower levels of fragmentation were characteristic of areas further from the main settlements.

In general single parcel farms were found throughout the total study area, while farms with two or more parcels tended to be concentrated in areas of traditional farming rather than in modern farming areas.

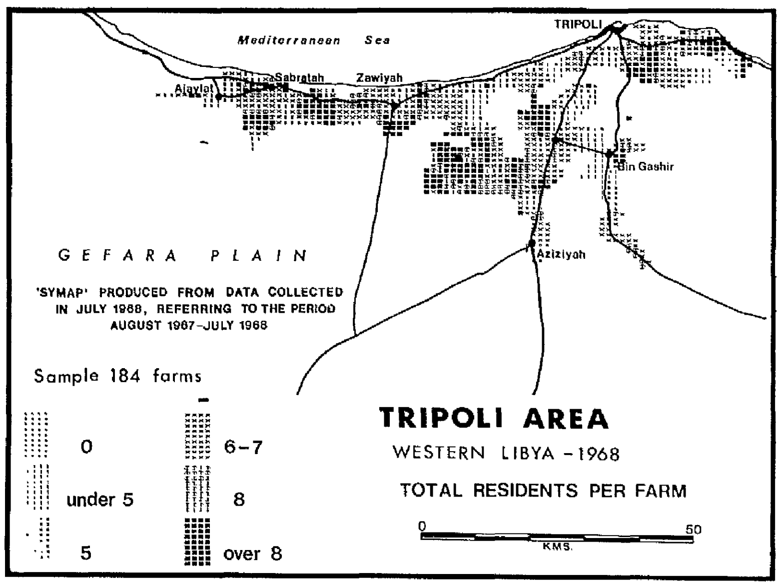
3.2 Rural population, farm ownership and housing

Figure 3.4 showing the total residents per farm indicates that the small traditional farms supported relatively few residents. The low numbers per farm around Zawiyah, where farms were small (except to the east of the town) is especially clear, as were the few farms with eight residents on the traditional farms north of the east-west highway and the area around Ajaylat.

Conversely the large modern farms around Az Zahrah, Suwani bin Yadim, and to the south east of Tripoli frequently showed over eight residents per farm.

In terms of density per hectare the picture was very different (Fig.3.5). High densities (2 to 4 residents per hectare) were revealed for the traditional farms especially near the main settlements, Zawiyah, Zanzur, Ajaylat and in the gardens east of Tripoli. On the other hand Az Zahrah, Suwani bin Yadim and Bin Gashir although having a high density per farm, had a very low density per hectare with less than 0.5 residents per hectare on average.

FIG 3.4


Mediterranean Sea
TRIPOLI
Sabratah
Zawiyah
Ajaylat
Bin Gashir
Aziziyah
GEFARA PLAIN
'SYMAP' PRODUCED FROM DATA COLLECTED IN JULY 1968, REFERRING TO THE PERIOD AUGUST 1967-JULY 1968
Sample 184 farms
0
under 5
5
6-7
8
over 8
TRIPOLI AREA
WESTERN LIBYA - 1968
TOTAL RESIDENTS PER FARM
0
50
KMS.

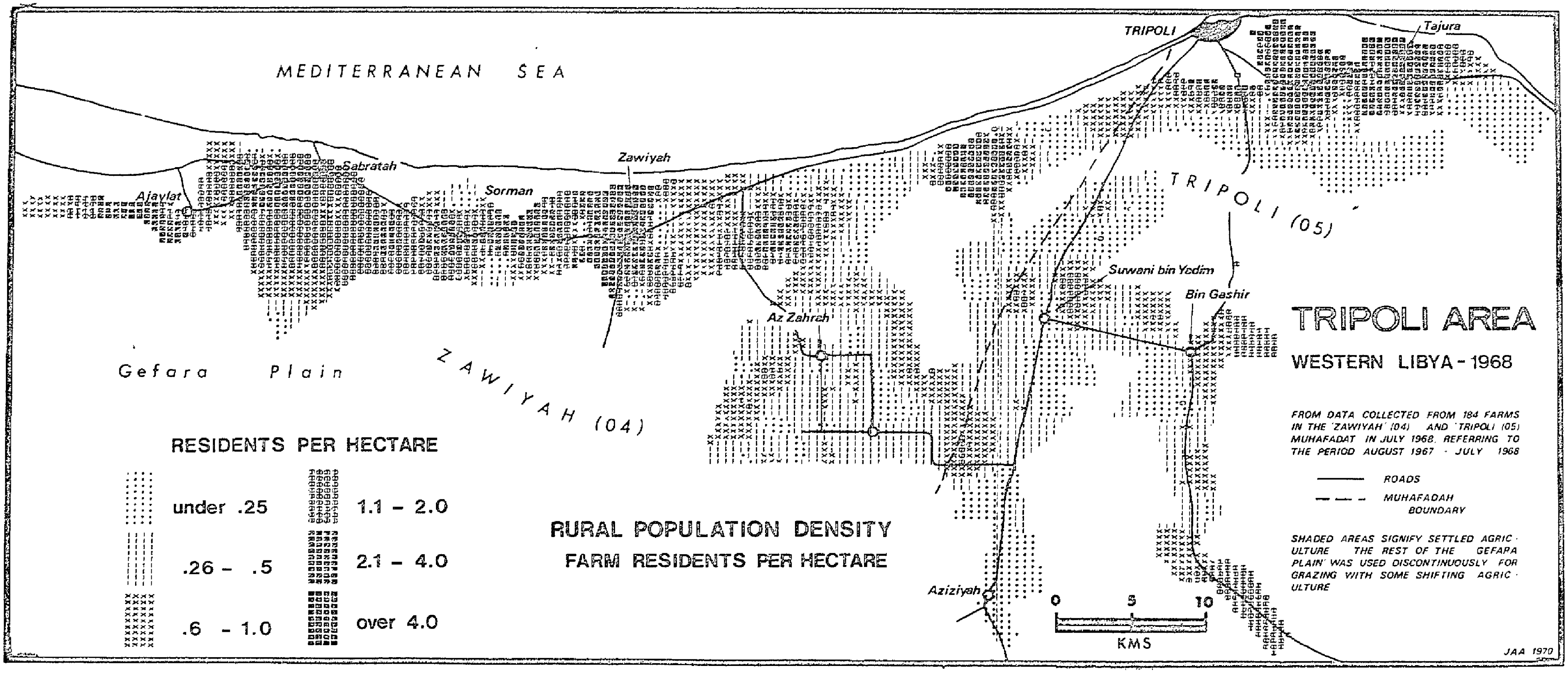

MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Ajaylat
Sorman
Zawiyah
Az Zahrah
Suwani bin Yedim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND 'TRIPOLI' (05) MUHAFADAT IN JULY 1968, REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE. THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
RESIDENTS PER HECTARE
under .25
.26 - .5
.6 - 1.0
1.1 - 2.0
2.1 - 4.0
over 4.0
RURAL POPULATION DENSITY
FARM RESIDENTS PER HECTARE
0
5
10
KMS
JAA 1970

FIG 3.5

The length of occupation of the farm was another characteristic showing an areal distribution, and which in this case can be interpreted in terms of recent events. The joint project data(3) showed that many modern irrigated farms (Farm type 2) changed hands after 1960, with 48% of these farms being acquired by new owners up to 1968. For traditional farms the figure for the same period was only 19%. Independence in 1951 was another occasion to stimulate the sale of farms, with a number of Italian farmers returning to Italy. Between 1951 and 1960 28% of the modern irrigated farms were bought by new owners, while 31% of traditional farms were passed on by normal inheritance.

Clearly the period since 1961 with its increased prosperity has provided the opportunity for Libyan farmers to acquire land, and almost twice as many Libyan farmers took over old Italian farms between 1961 and 1968 as in the December 1951-1960 period. It would appear that about 3% of traditional farms change hands through inheritance each year. This can be compared with the 6% per year which is the rate at which modern farms were being bought between 1960 and 1968.

Some of the above changes in ownership are illustrated in Figure 3.6. Areas of modern farming to the south east, and east of Zāwiyah, also around Az Zahrah and Suwani bin Yadim indicate that they were acquired certainly since independence in 1951 and often, especially around Az Zahrah, since 1960. Elsewhere the map (Fig.3.6) does not indicate significant trends. The ownership of farms for more than 24 years, and the normal inheritance of such farms, by either Libyan or Italian farmers prevents traditional and modern farms being distinguished.

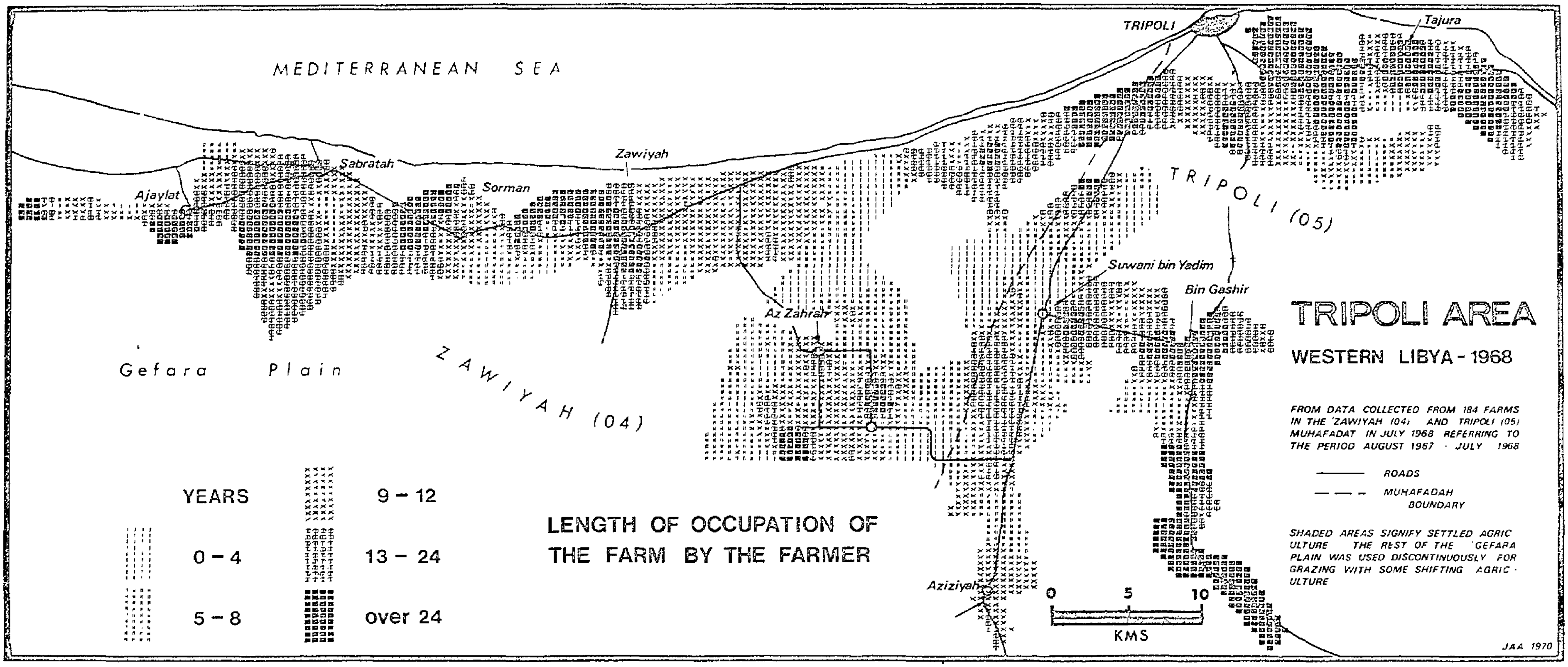

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
LENGTH OF OCCUPATION OF THE FARM BY THE FARMER
YEARS
0 - 4
5 - 8
9 - 12
13 - 24
over 24
MEDITERRANEAN SEA
Gefara Plain
ZAWIYAH (04)
TRIPOLI (05)
TRIPOLI
Tajura
Ajaylat
Sabratah
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
0
5
10
KMS
JAA 1970

FIG 3.6

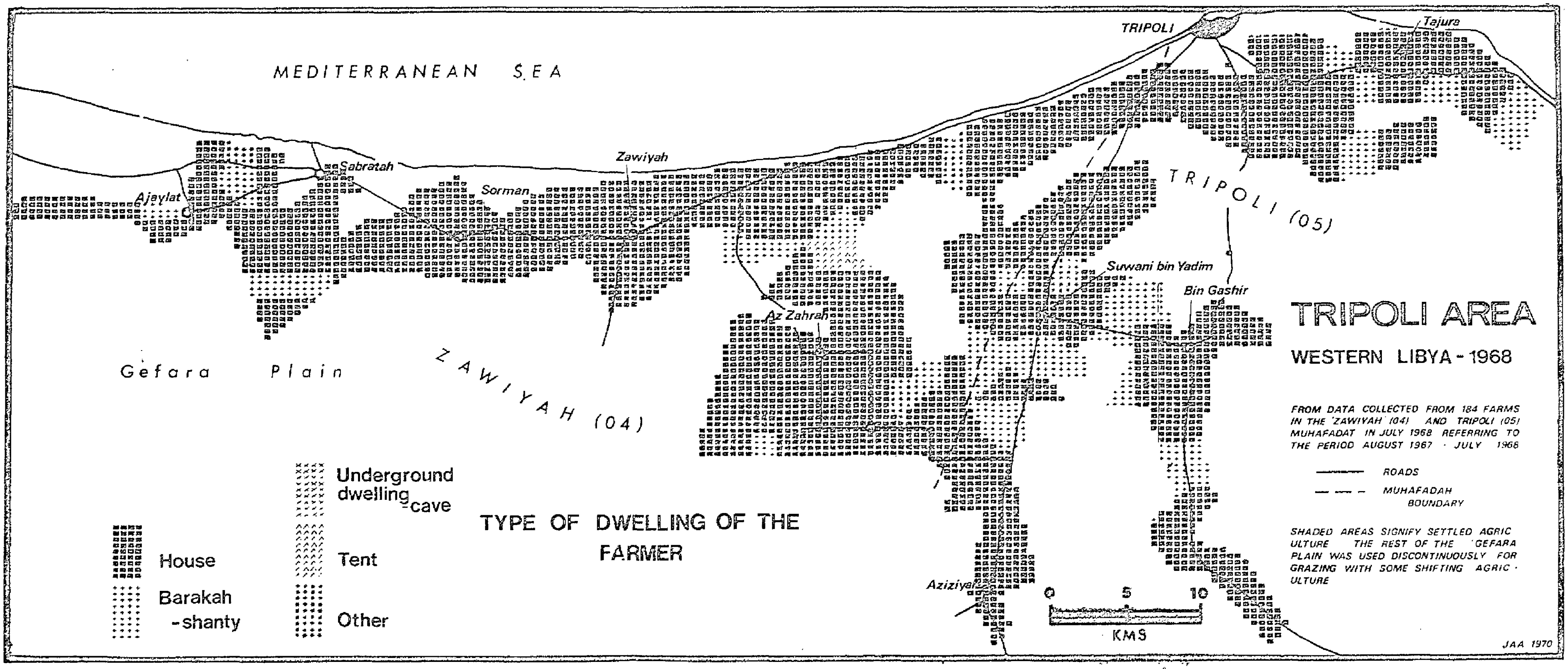

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE 'GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
TYPE OF DWELLING OF THE FARMER
House
Barakah -shanty
Underground dwelling-cave
Tent
Other
MEDITERRANEAN SEA
Gefara Plain
ZAWIYAH (04)
TRIPOLI (05)
TRIPOLI
Tajura
Ajaylat
Sabratah
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
0
5
10
KMS
JAA 1970

FIG 3.7

It is similarly difficult to distinguish traditional and modern farms by means of the type of dwelling of the farmer, which is shown in Figure 3.7. The main impression gained from this map is that the Libyan farming community near Tripoli was almost wholly housed in permanent dwellings. The few shanty dwellings which did exist were, according to the sample, located on modern farms (except in one case near Ajaylat). The location of shanties on modern farms is explained by the comparatively recent acquisition of these farms, and it was often found that the farmer was living in a temporary dwelling before completing a new house. The building of such new houses was necessary when an old Italian farm had been sold in smaller lots. Only the plot with the original farm-house was provided with a dwelling, and additional building was necessary on the others.

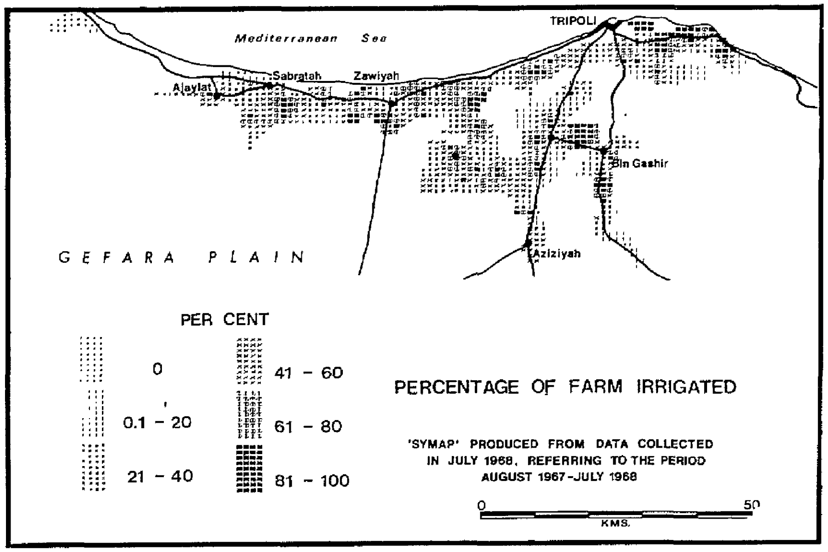
There were many shanty dwellings on the modern farms not shown on Figure 3.7, because these shanties did not belong to the owner, and all data from the sample farms related only to the owner. The shanties belonged to recently settled farm workers, who had come mainly from Tunisia since 1960.

3.3 Type and intensity of cultivation

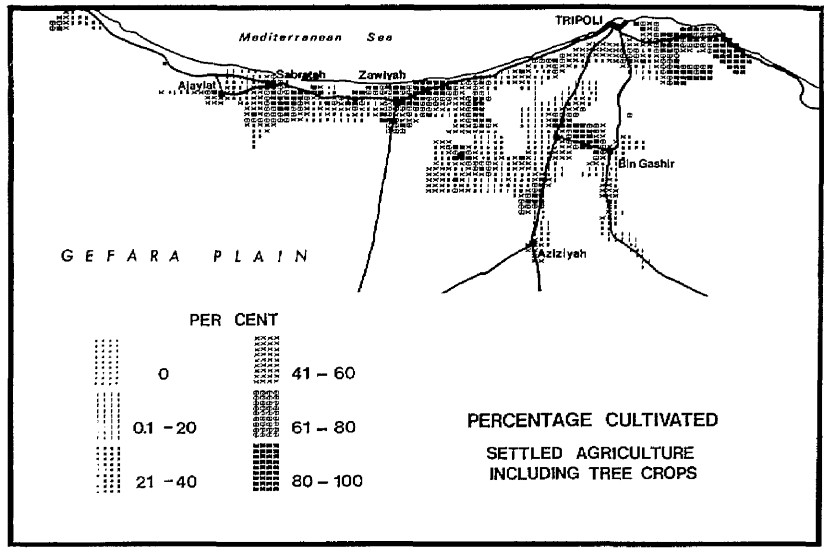
It is revealed in Figures 3.8 & 3.9 that the Tripoli triangle was not very intensively farmed. On average just under 50% of the sampled farm areas was cultivated in 1968, with the lowest figures being evident in the Az Zahrah area and the other modern farming areas to the east, as well as to the south west of Tripoli.

Clearly cereal crops were not important (see Fig.3.9) since on average under 20% of the farm was under cereals in 1968. It should be remembered that cereals are not irrigated in Libya (except summer maize, which is not a common crop) and therefore yields are low.

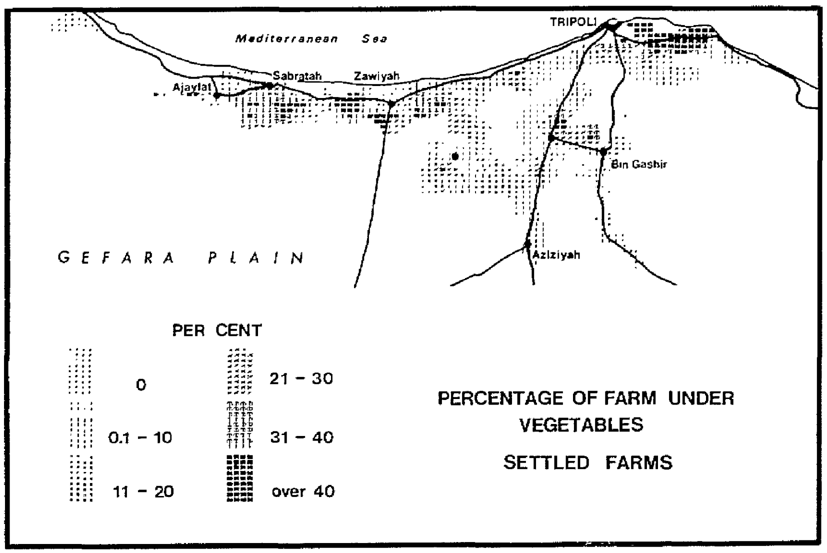
TRIPOLI AREA - WESTERN LIBYA



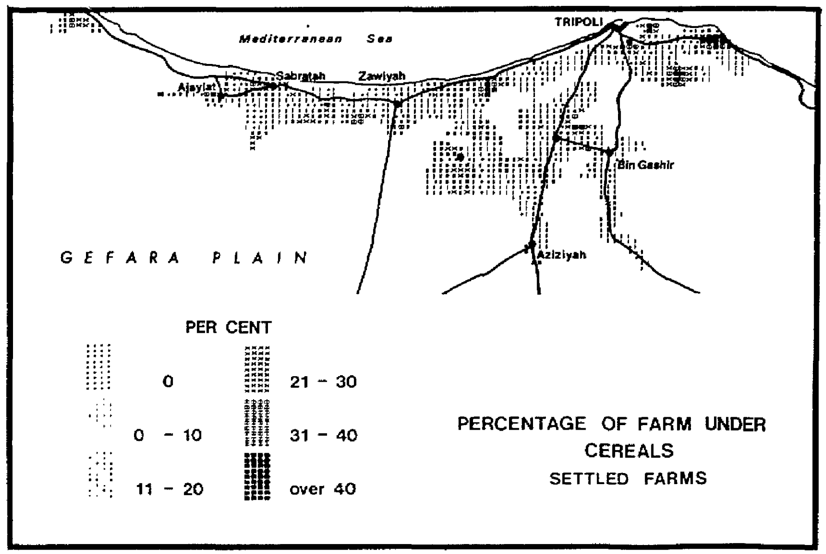
3.10



3.8



3.11



FIGURES 3.9

From data collected from 184 farms in the Tripoli & Zawiyah muhafadat.

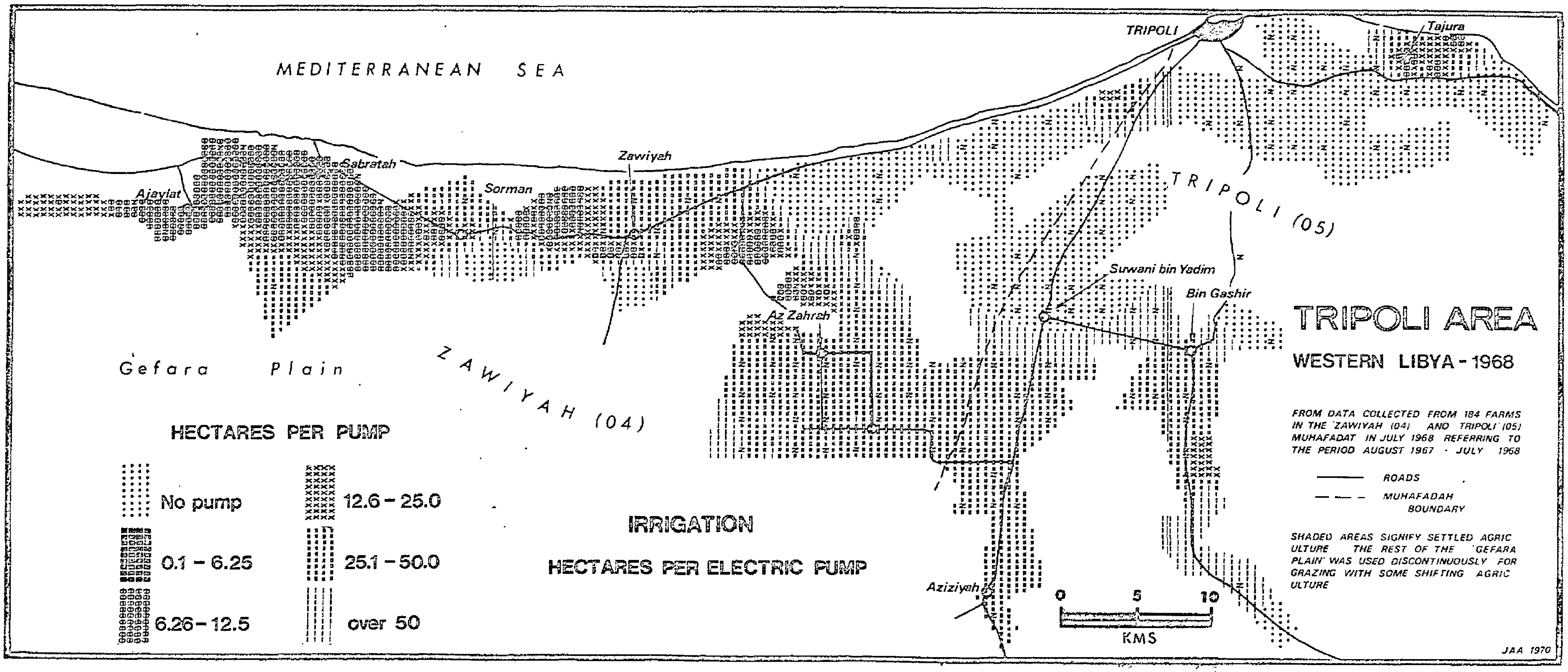
As a result, in terms of income, cereals contributed much less than 20% of the farm income, even when taking up perhaps 50% of the cultivated area.

The more valuable cash crops were the irrigated vegetables, and such crops as groundnuts and melons. Figure 3.10 indicates that on average between 30% and 40% of a farm in the Tripoli area was irrigated. This was a much higher proportion than anywhere else in Libya except a small area to the south of Misuratah. Vegetables were also a more important crop than elsewhere in Libya, so that in the study area just under 20% of agricultural land was under vegetables in 1968. Fieldwork indicated that farmers engaged in growing vegetables would also be interested in raising the other important cash crops, tomatoes, groundnuts, melons and alfalfa. The dominant vegetable growing area was close to Tripoli, both in the traditional gardens just to the east of the city, and on the modern farms between seven and fifteen kilometres further to the east.

3.4 Irrigation

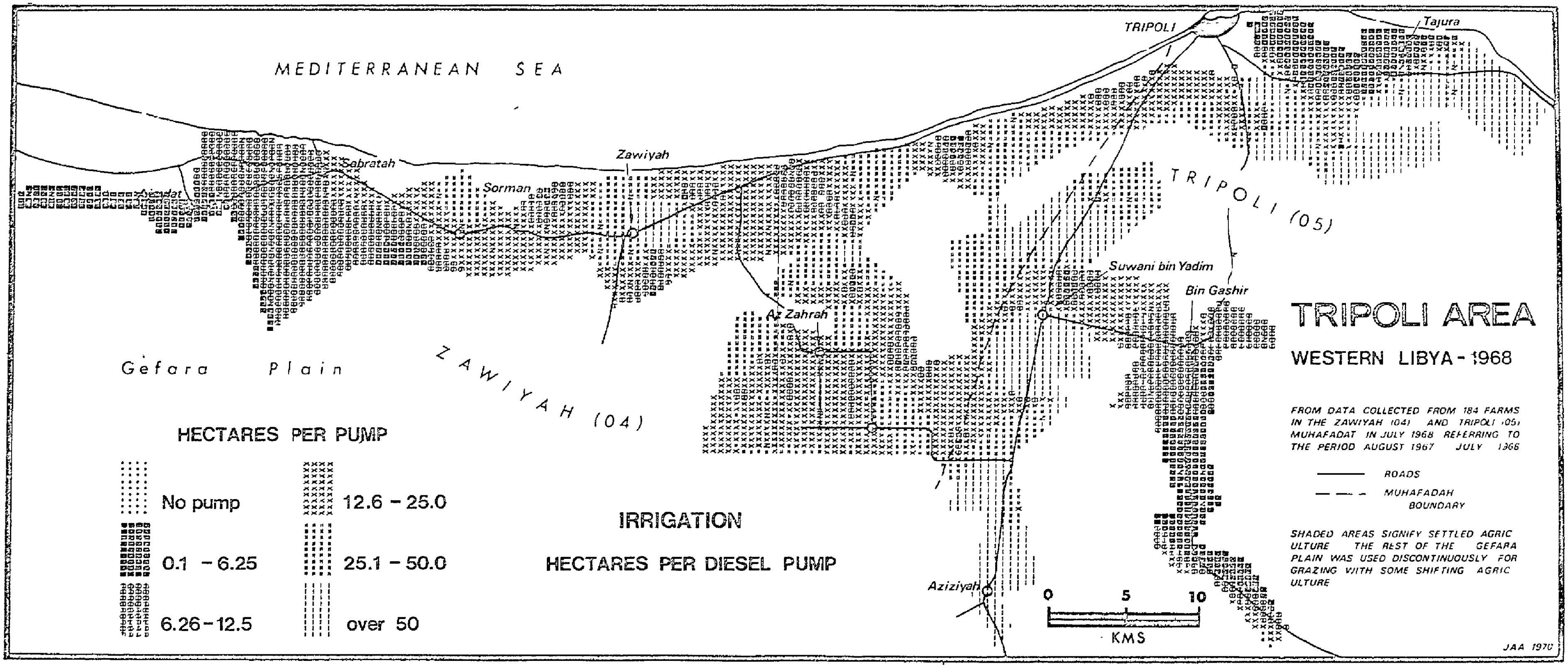
It has already been shown that the Tripoli triangle was the most heavily irrigated area of Libya. This proposition is further confirmed by maps showing the distribution of types and densities of pumping equipment (Figures 3.12, 3.13 and 3.14). Electric pumps, diesel pumps and spray pipes all showed a higher usage per hectare in the total study area than elsewhere in the Western Provinces.

Electric pumps showed up as the most popular form of equipment generally, and were especially preferred westwards of Zanzur, around Zawiyah and Sabratah. Electric pumps were common in the southern part of the Az Zahrah area, and southwards from Bin Gashir along the main road to Tarhunah.



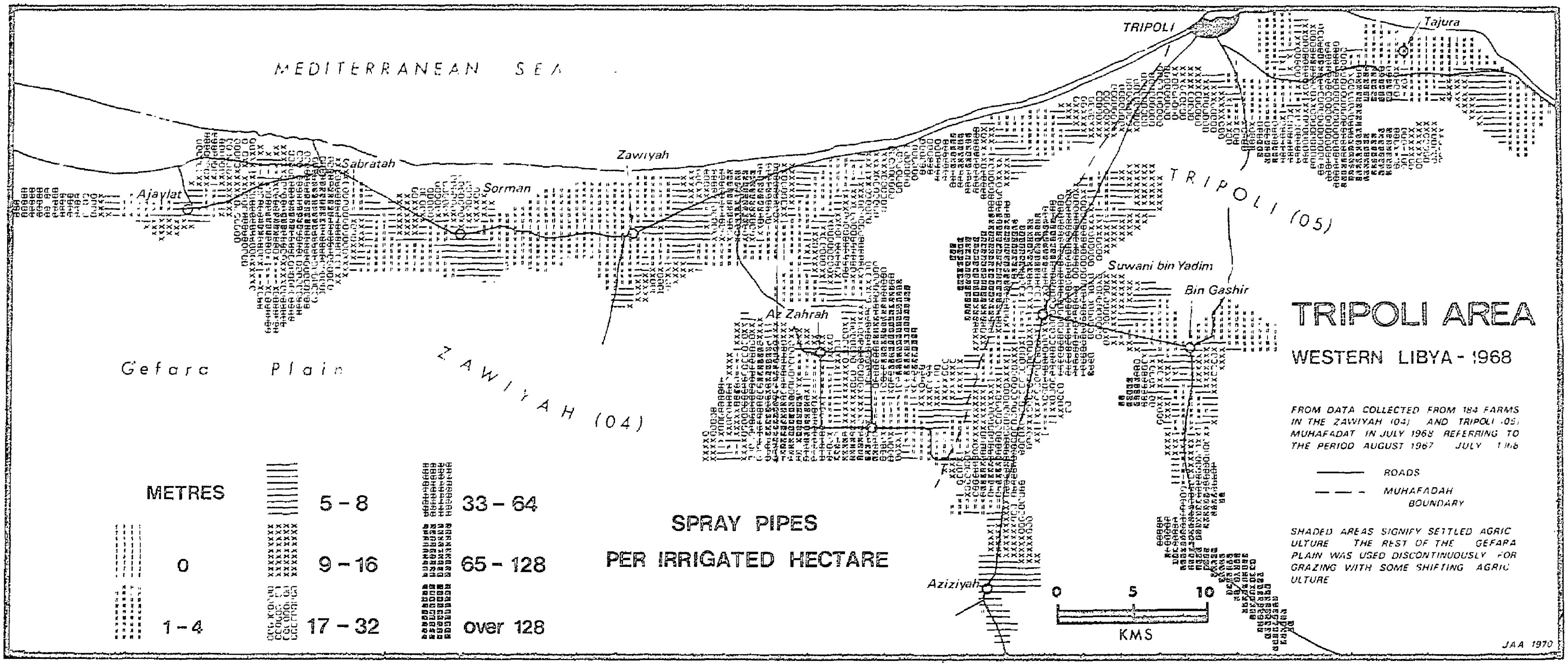
MEDITERRANEAN SEA
TRIPOLI
Tajura
Zawiyah
Sabratah
Ajaylat
Sorman
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH (04) AND TRIPOLI' (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
HECTARES PER PUMP
No pump
0.1 - 6.25
6.26 - 12.5
12.6 - 25.0
25.1 - 50.0
over 50
IRRIGATION
HECTARES PER ELECTRIC PUMP
0
5
10
KMS
JAA 1970

FIG 3.12



MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Zawiyah
Sorman
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
HECTARES PER PUMP
No pump
0.1 - 6.25
6.26 - 12.5
12.6 - 25.0
25.1 - 50.0
over 50
IRRIGATION
HECTARES PER DIESEL PUMP
0 5 10
KMS
JAA 1970

FIG 3.13



TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
MEDITERRANEAN SEA
TRIPOLI
Tajura
TRIPOLI (05)
Suwani bin Yadim
Bin Gashir
Zawiyah
Sabratah
Sorman
Ajaylat
Az Zahrah
Aziziyah
Gefara Plain
ZAWIYAH (04)
METRES
0
1 - 4
5 - 8
9 - 16
17 - 32
33 - 64
65 - 128
over 128
SPRAY PIPES
PER IRRIGATED HECTARE
0 5 10
KMS
JAA 1970

FIG 3.14

Complementary areas using mainly diesel pumps showed up just to the east of Tripoli, also in the Suwani bin Yadim/Bin Gashir area and fairly generally in the Az Zahrah area.

The average density of pumping equipment was approximately 10 hectares per pump, although those areas actively engaged in irrigation normally had between three and five hectares per pump. Pumps varied considerably in size, but were normally under five horse power, except on the very large modernised farms, where ten horse power pumps were not uncommon.

The use of spray pipes for distributing the irrigation water was a useful indicator of the type of farming, and of the progress of investment. Figure 3.14 shows the distribution of this equipment in the Tripoli triangle, which was again shown to be the area of highest usage in the Western Provinces according to results of the Joint Research Project survey. Over 100 metres per hectare was not uncommon, and 50 metres per hectare was the average for modern farms. Traditional farms scarcely used spray pipes, as can be confirmed by looking at farms north of the main east-west highway (Fig.3.14). Some traditional farms near Ajaylat had begun to use spray irrigation, but as will be shown later this was an area where considerable changes were taking place in agricultural methods, as well as being an area scarcely affected by the period of Italian colonisation. Recent investment has therefore been high in what had been a neglected region.

3.5 Mechanisation

Tractors have been taken as the main indicator of mechanisation, other than irrigation. There were approximately 25 hectares per tractor in the Tripoli triangle according to the 1968 data, again a rather more advantageous density of equipment than elsewhere in the Western Provinces. There were very few tractors on traditional farms,

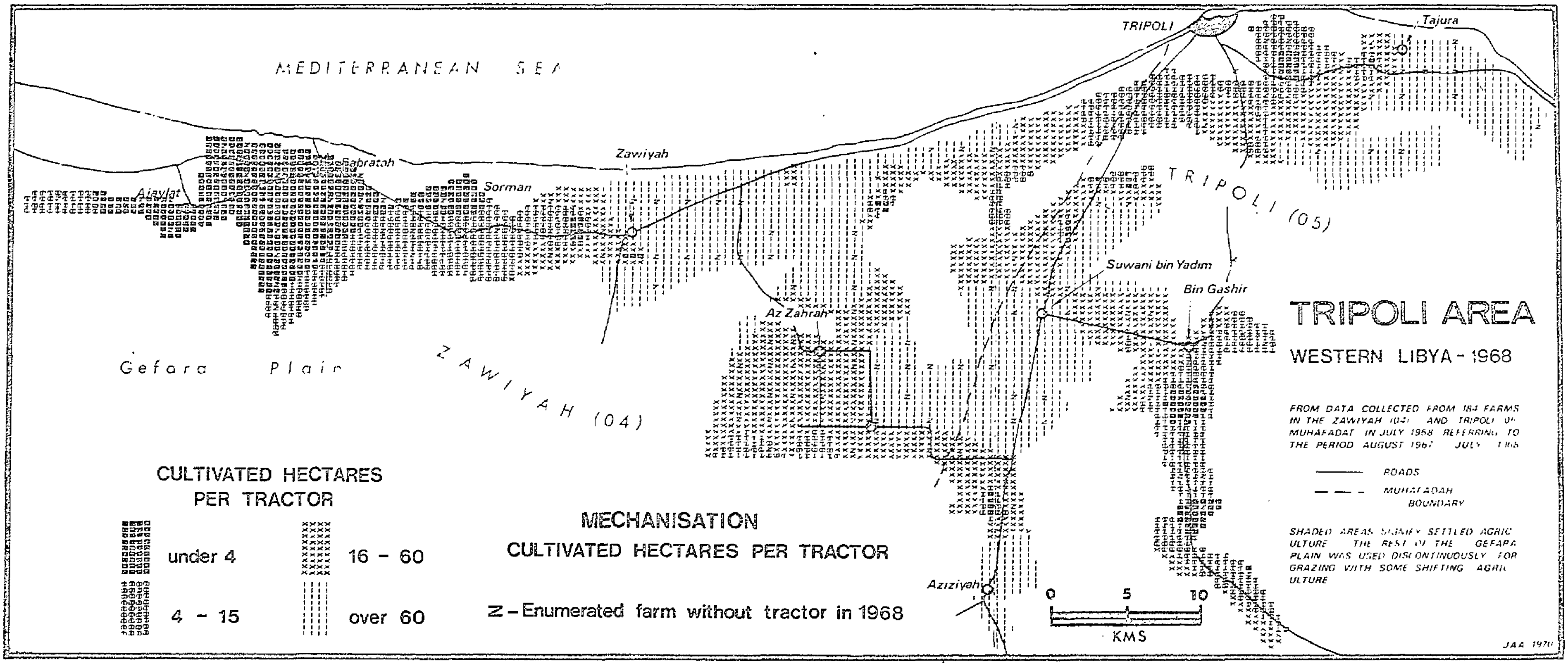

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
MEDITERRANEAN SEA
TRIPOLI
Tajura
TRIPOLI (05)
Suwani bin Yadim
Bin Gashir
Zawiyah
Sorman
Sabratah
Ajaylat
Az Zahrah
Aziziyah
ZAWIYAH (04)
Gefara Plain
CULTIVATED HECTARES PER TRACTOR
under 4
4 - 15
16 - 60
over 60
MECHANISATION
CULTIVATED HECTARES PER TRACTOR
Z - Enumerated farm without tractor in 1968
0 5 10
KMS
JAA 1970

FIG 3.15

except south of Sabratah (an area similar to Ajaylat which will be described in more detail later), while modern farms were equipped at the 25 cultivated hectares per tractor level. (see Figure 3.15)

3.6 Labour intensity

Labour intensity is shown to differ considerably from place to place in Figures 3.16 and 3.17, depending upon whether the work force* has been related to the total area of the farm, or merely to the cultivated area. Figure 3.16 shows that in relation to the total farm there was on average one worker per five hectares on modern farms. The same density was found on traditional farms, except to the east of Tripoli in Suq al Juma, Jadidah and Talbighah, where rather more permanent workers were employed, bringing the average to under two hectares per permanent worker.

In terms of the cultivated area in 1968 the density was very much higher on all farms. Modern farms had approximately one permanent worker per cultivated hectare, while traditional gardens employed much more labour averaging over two workers per cultivated hectare. This last reflects the much higher density of female and male child labour on traditional farms than on modern holdings and their dependence on less mechanised methods such as the basin (or 'gadula') method of irrigation. The much lower level of mechanisation on traditional farms was also relevant, which has been discussed in paragraph 3.5.

The two very large farms (over 3000 hectares)-that near Aziziyah, and the other in the extreme east of the area, show a very low labour density in terms of cultivated area, with less than one worker per four hectares.

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* The work force includes resident workers throughout this discussion.

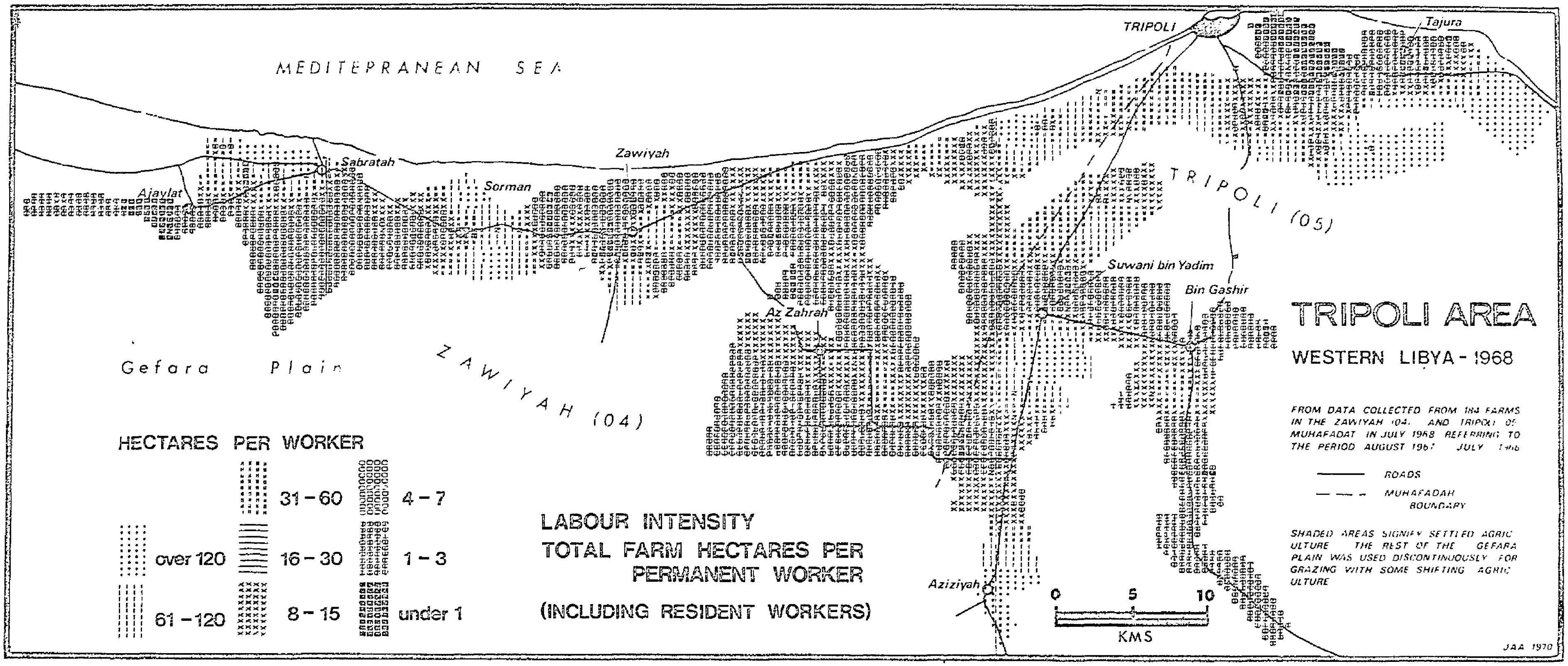

MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Ajaylat
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
0 5 10
KMS
HECTARES PER WORKER
over 120
61 - 120
31 - 60
16 - 30
8 - 15
4 - 7
1 - 3
under 1
LABOUR INTENSITY
TOTAL FARM HECTARES PER PERMANENT WORKER
(INCLUDING RESIDENT WORKERS)
JAA 1970

FIG 3.16

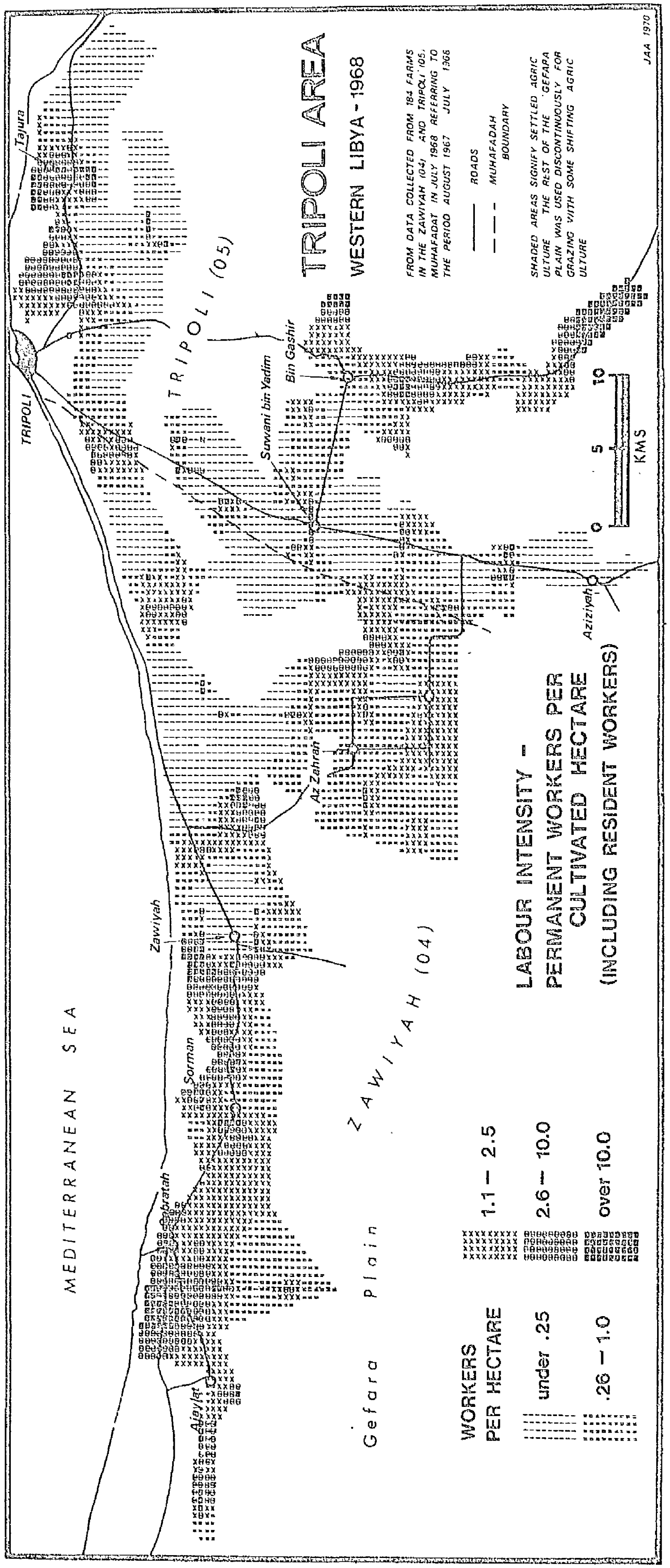

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE. THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
JAA 1970
MEDITERRANEAN SEA
Tajura
TRIPOLI
TRIPOLI (05)
Bin Gashir
Suwani bin Yadim
Aziziyah
Az Zahrah
Zawiyah
ZAWIYAH (04)
Sorman
Sabratah
Ajaylat
Gefara Plain
0 5 10
KMS
LABOUR INTENSITY -
PERMANENT WORKERS PER
CULTIVATED HECTARE
(INCLUDING RESIDENT WORKERS)
WORKERS PER HECTARE
under .25
.26 – 1.0
1.1 – 2.5
2.6 – 10.0
over 10.0

FIG 3.17

This lower density on modern farms was confirmed by other figures which break down the permanent workers in respect of men, women and boys.(4) Traditional farms had as high a number of female and

TABLE 3.1

	Traditional irrigated farms (Type 1)	Modern irrigated & semi-irrigated (Type 2)
Average farm size	4.0 ha.	31.3 ha.
Average workers - male	2.35	6.19
female	2.29	2.24
boys	2.76	2.79

Permanent workers per farm - Western Provinces - 1968.

Source: Libyan University-London University Joint Project LIBYA, Volume 3, pp.132-133, 1970.

boy workers per farm as the modern farm despite being on average one eighth their size (see Table 3.1). Modern farms had almost three times as many male workers per farm, but again the larger size of the modern farm brought the density of male labour to one worker per five hectares compared with one per two hectares on traditional farms. Female and boy labour, which was almost always resident labour, except on a few modern farms, worked out to be one female worker per 1.7 hectares on traditional farms, compared with one per 15 hectares on modern farms. Boy labour was one boy per 1.4 hectares on traditional farms and only one per 11 hectares on modern holdings.

The productivity of the labour was impossible to measure since neither the input of time, nor the activity and regulation of the labour have been recorded. Labour on modern farms was likely to be more productive since these farms were more highly mechanised, with tractors and more efficient irrigation equipment, and therefore it is not unreasonable to suggest that labour on modern farms was twice as productive as on traditional holdings, and possibly more so.

The degree of underemployment of permanent workers on both traditional and modern farms was difficult to determine. It certainly existed on both types of farm, but was more readily disguised on the small traditional holdings, where the family element in the permanent labour force was higher. Traditional farms had between six and seven residents (see Fig.3.14) on average (including children) and employed approximately seven workers on some sort of permanent basis. Modern farms had over eight residents per farm on average and employed eleven permanent workers. Resident labour was more important therefore on the traditional farms, and since it was difficult to be sure of the 'permanence' of this family labour, despite careful questioning at the time of the questionnaires, the greater importance of family labour on traditional farms made it likely that the gross output per worker of labour on such farms was lower.

3.7 Investment

Farm investment is shown for the 1967/1968 agricultural year in Figures 3.18 & 3.19. Investment in housing and house improvement has been shown separately in Figure 3.19, because the significance of such investment was clear in the field, in air photographs, and from a preliminary examination of the investment figures.

The computer maps show certain patterns in investment very clearly, patterns confirmed by further analysis of the data. Investment on the small traditional farms in the 'Tripoli triangle' was at a much higher rate per hectare than on modern farms. Joint Research Project

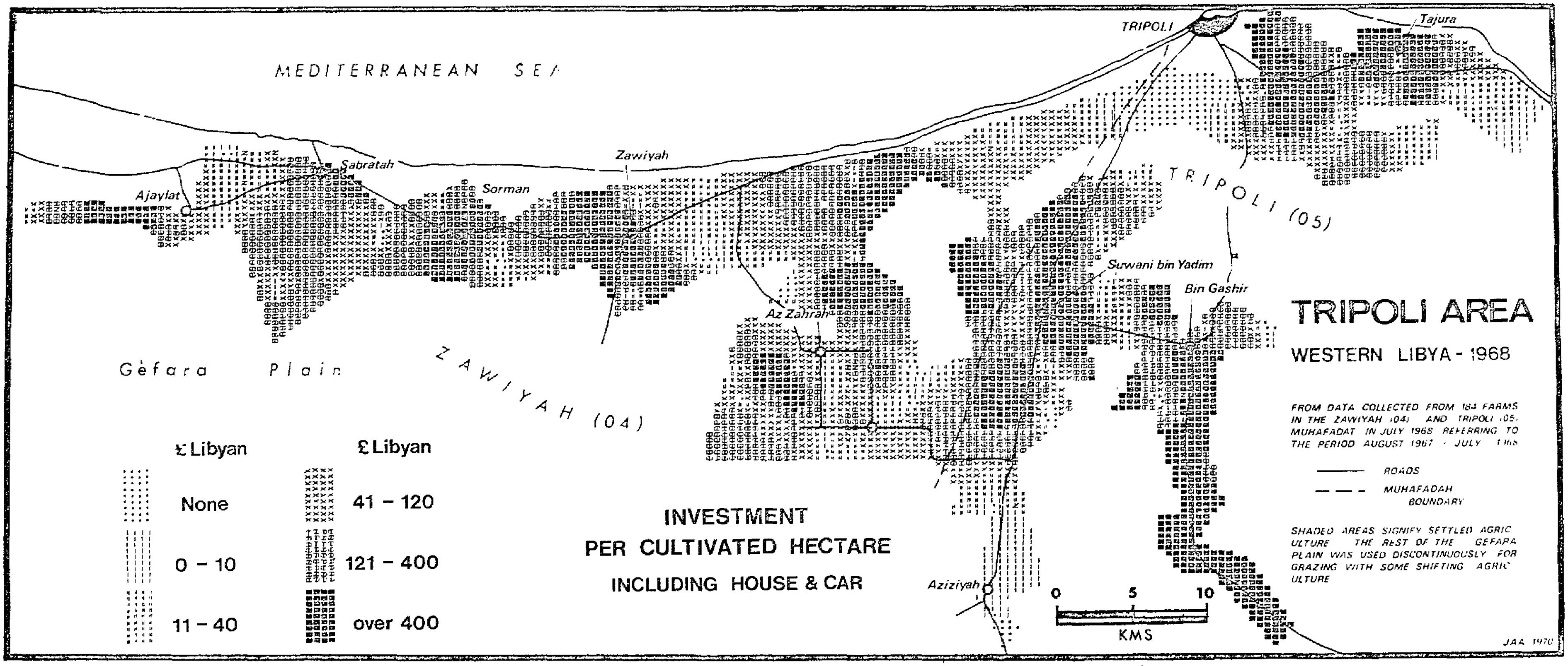
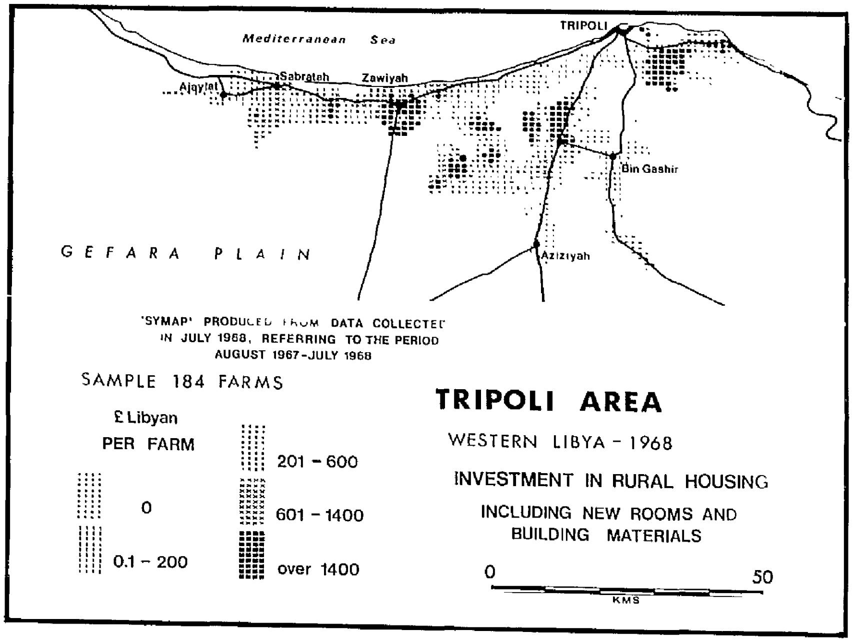

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE. THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
MEDITERRANEAN SEA
Tripoli
Tajura
TRIPOLI (05)
ZAWIYAH (04)
Suwani bin Yadim
Bin Gashir
Az Zahrah
Zawiyah
Sorman
Sabratah
Ajaylat
Aziziyah
Gefara Plain
INVESTMENT
PER CULTIVATED HECTARE
INCLUDING HOUSE & CAR
£ Libyan
None
0 - 10
11 - 40
£ Libyan
41 - 120
121 - 400
over 400
0 5 10
KMS
JAA 1970

FIG 3.18

FIG 3.19



TRIPOLI AREA

WESTERN LIBYA - 1968

INVESTMENT IN RURAL HOUSING

INCLUDING NEW ROOMS AND BUILDING MATERIALS data[5] for Western Libya for 1967/68 shows that investment per cultivated hectare was running at £L 88 on traditional irrigated farms, and at £L 742 per farm. Conversely total investment per farm was running at a much higher level of £L 2631 on modern farms, but the rate per cultivated hectare was only £L 25.

TABLE 3.2

Investment on 'Traditional' and 'Modern' Farms - Western Libya - 1967/68

	Investment £L Libyan		Average size
	Per Farm	Per cultivated ha.	
Traditional Irrigated Farms	£L 742	£L 88	4.0 ha.
Modern Irrig'd & Semi-Irrig'd	£L 2631	£L 25	31.3 ha.

Source: Joint Project Data. Volume 1. pp.145 & 146.

Because traditional farms were often located near the main centres, for example near Ajaylat, Sabratah and Zawiyah, these show up as areas of high total investment per hectare, as did the traditional farms on the coast to the east of Tripoli (Suq al Jumah and Tajura).

The degree of investment ranged widely on modern farms, with the highest levels at £L 140 per hectare for the whole farm, and up to £L 400 per cultivated hectare on such farms to the south east of Tripoli. However, equivalent figures for the Az Zahrah area, also a region of modern holdings, were approximately £L 40 for the total farm and under £L 120 for the cultivated area. Housing investment was shown to be at the rate of over £L 1400 per farm in the former area, while in Az Zahrah, where Italian farm houses existed, and there had been little splitting up of the original holdings, housing investment ran at between £L 200 and £L 600 per farm on average.

Details of farm investment other than housing were revealing of the trends in the different types of farm. Farmers on traditional farms were spending a much smaller proportion of their investment resources on irrigation equipment and machinery than farmers with modern holdings. (See Table 3.3)

TABLE 3.3

Investment

Distribution of Main Types of Farm Investment

'Traditional' and 'Modern' Farms

1967/68.

	TRADITIONAL FARMS		MODERN FARMS	
	£L	%	£L	%
Real Property and Construction (Homes and Rooms)	436 (371)	57 (49)	973 (474)	37 (18)
Irrigation Equipment	121	16	842	32
Machinery	60	8	526	20
Transport	116	17	210	8
Land Reclamation	9	1	79	3
Total Investment	742	100	2630	100

Source: Joint Research Project Data. Volume 1. pp. 145 & 146.

Heavy farm investment dated from three to four years before the Joint Project survey. It was therefore at a relatively early stage, and farmers on traditional farms were concentrating on house replacement. It was not possible to establish whether such farmers would turn next to equipment purchase. It seemed unlikely on the basis of questioning in the field. Farmers with modern holdings on the other hand were concentrating much more than their traditional counterparts on the extension of irrigation and were heavily committed to the purchase of irrigation equipment.

3.8 'Off-farm' Employment

The extent of off-farm employment has been mapped in Figures 3.20 and 3.21. 25% of farmers had 'off-farm' employment, 17% full-time and 8% part-time. In turn 30% of farms had an eldest son who worked off the farm, one third of whom did agricultural work.

Working for the government was the most popular form of 'off-farm' employment for the farm owner. 42% had jobs with the police or a ministry of the government. Retail trading was the next most important employer with 26% of such farmers.

The breakdown was significantly different for traditional and modern farm owners, although the total proportion engaged in such work was very similar, at 27% for traditional farms and 24% for modern holdings. Government employment was much more popular on modern farms, with 51% in this type of work, compared with 27% on traditional farms. Retail trading featured most strongly for traditonal farmers, however, with 42% doing this work compared with only 16% of the modern farmers who worked off the farm.

The high degree of government employment on modern farms is reflected in Figures 3.20 & 3.21, where the dispersion of off-farm employment is displayed. I expected off-farm employment to be closely related to settlement, with farmers living close to Tripoli and the large towns being most frequently employed off the farm. Figure 3.20 and 3.21 reveal that farmers from all parts of the agricultural Tripoli triangle sought work off the farm, and were able and prepared to travel considerable distances for such work. While engaged in fieldwork I did give a number

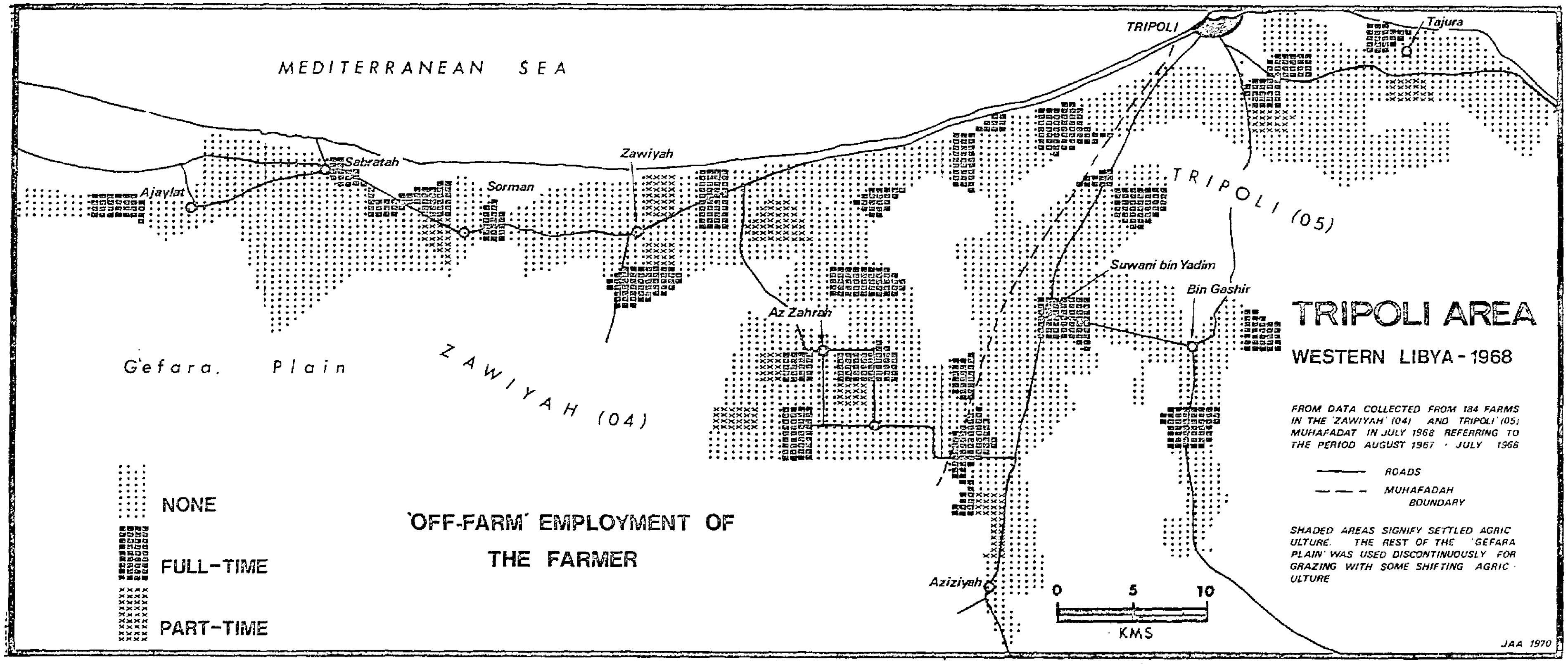

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND TRIPOLI' (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE. THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
'OFF-FARM' EMPLOYMENT OF THE FARMER
NONE
FULL-TIME
PART-TIME
MEDITERRANEAN SEA
TRIPOLI
Tajura
Ajaylat
Sebratah
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI (05)
ZAWIYAH (04)
Gefara Plain
0
5
10
KMS
JAA 1970

FIG 3.20

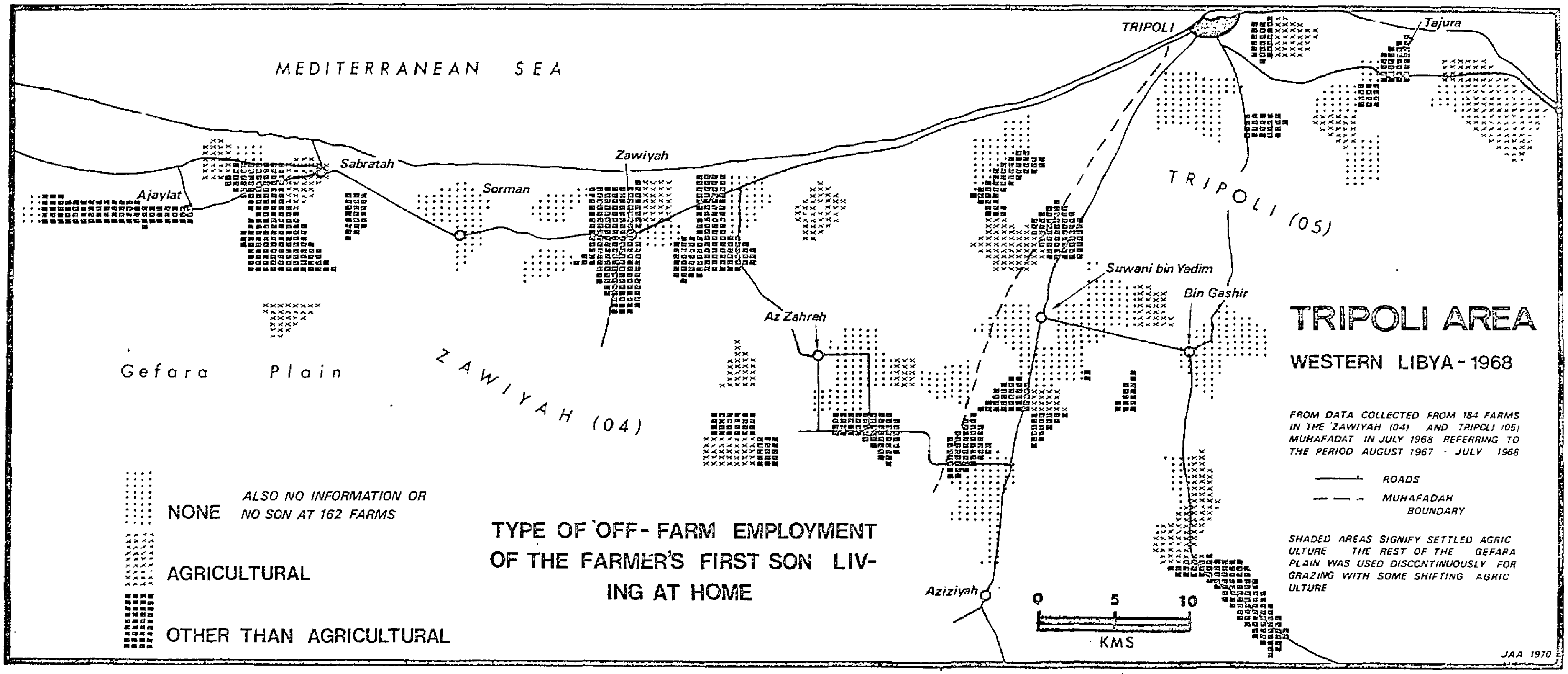

MEDITERRANEAN SEA
TRIPOLI
Tajura
Sabratah
Ajaylat
Zawiyah
Sorman
Gefara Plain
ZAWIYAH (04)
TRIPOLI (05)
Az Zahreh
Suwani bin Yadim
Bin Gashir
Aziziyah
TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
NONE
ALSO NO INFORMATION OR NO SON AT 162 FARMS
AGRICULTURAL
OTHER THAN AGRICULTURAL
TYPE OF 'OFF-FARM EMPLOYMENT OF THE FARMER'S FIRST SON LIVING AT HOME
0
5
10
KMS
JAA 1970

FIG 3.21

of farmers and their sons casual 'lifts' to and from work in Tripoli from farms up to 40 kilometres from the city. They worked as school teachers, or for a ministry or in the Tripoli docks in a clerical capacity.

Through the wage payments to these farmers and their sons, the increased wealth of the country had been distributed to the employed population, in this case also the farming community. The importance of such income in terms of farm investment must be emphasised especially as the extended family system was strong in which the father, usually the farm owner, controlled the family expenditure and policy.

This descriptive chapter has been included to summarise as briefly as possible by cartographic means the arrangement of important agricultural variables in the total study area. It is against this background that the later case studies of selected areas should be viewed.

CHAPTER 4.

THE PHYSICAL RESOURCES OF THE STUDY AREA AND ESPECIALLY OF THE TWO CASE STUDY AREAS, TO SHOW THE GENERAL DEPENDENCE ON IRRIGATION AND THE INADEQUATE UNDERGROUND WATER RESOURCES OF COASTAL LIBYA

4.1 Climate and Crop Ecology

The climate of coastal Libya follows the Mediterranean pattern. Rainfall occurs in the winter months, between October and April. Maximum temperatures can be recorded at any time between May and September. Such maxima often arise in association with the 'ghibli' wind, the extremely hot, dry and sometimes dusty wind off the southern deserts, which is drawn north by low pressure systems passing through the Mediterranean. Since these conditions can arise at any season, the damaging winds may come at any time, but are most destructive and uncomfortable in spring and summer.

Climatic Data

Temperature and rainfall data relevant to the two field areas can be found in Appendix 2. They cover in some detail the fifteen years (1953-1968), and where possible mean figures for a longer period are shown.

4.1.1 Temperature

The study area lies in a relatively flat plain (maximum elevation 120 m.). There is therefore a predictable change in climatic character with distance from the sea and these changes are not at any place overridden by the effects of irregular relief.

Table 4.1.1 demonstrates clearly how important is the effedt of the proximity of the sea, both on temperature and humidity. Temperatures show a much greater range at inland Aziziyah, with winter maxima 2-3°C down and summer maxima 5°- 6° up on coastal readings.

TABLE 4. 1.1

COMPARISON OF TEMPERATURE, AND HUMIDITY DATA
FOR COASTAL AND INLAND LOCATIONS ON THE GEFARA PLAIN

	Distance from coast km.	Approx elevation m.	MINIMUM TEMPERATURES °C				MAXIMUM TEMPERATURES °C			
			Winter*		Summer		Winter		Summer	
			Extreme	Mean	Extreme	Mean	Extreme	Mean	Extreme	Mean
			ACTUAL RECORDINGS (°C)							
Tripoli	0	15	-0.6	7.6	15.0	21.7	28.1	16.1	45.6	30.8
Airport/Bin Gashir	20	75	-1.2	5.3	13.1	19.2	31.5	18.2	50.6	36.9
Aziziyah	40	115	-3.2	5.4	10.4	20.1	30.4	17.5	51.0	37.6
			DIFFERENCES BETWEEN TRIPOLI AND OTHER STATIONS °C							
Tripoli	0	15	0	0	0	0	0	0	0	0
Airport/Bin Gashir	20	75	-0.6	+2.3	-1.9	-2.5	+3.4	+2.1	+5.0	+6.1
Aziziyah	40	115	-2.6	-2.2	-4.6	-1.6	+2.3	+1.4	+5.4	+6.8
			MEAN RELATIVE HUMIDITY %							
			Winter*				Summer			
Tripoli	0	15	62				65			
Airport/Bin Gashir	20	75	57				45			
Aziziyah	40	115	61				44			

* Winter is taken as January and Summer as August

Source: Meteorological Department, Ministry of Communications, Monthly and Annual Climatological Data for Libya, Tripoli, undated. pp. 3(1), 6(1) and 7(1).

The range of temperatures within the season, i.e. the difference between the minimum and maximum for one station in January or August is also greater inland, as the following figures illustrate.

TABLE 4.1.2

Comparison of extreme and mean minimum and maximum temperature records, Tripoli, Airport/Bin Gashir and Aziziyah

	Difference °C between			
	Extreme minima and maxima		Mean minima and maxima	
	January	August	January	August
Tripoli	28.7	29.4	8.5	9.1
Airport/Bin Gashir	32.7	37.5	12.9	17.7
Aziziyah	33.6	40.6	12.1	17.5

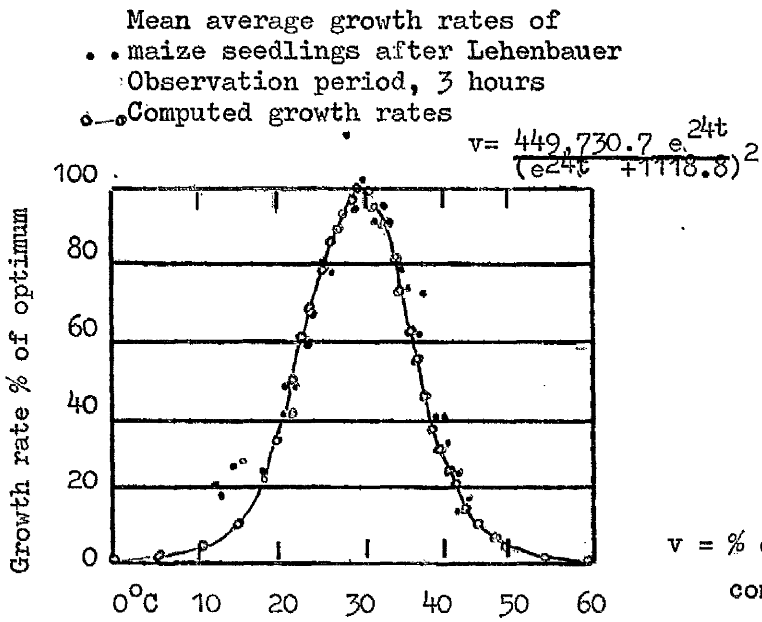
Source: Meteorological Department, Ministry of Communications, Monthly and Annual Climatological Data for Libya, Tripoli, undated, pp. 6(1) and 7(1).

The evidence from Tripoli, Airport/Bin Gashir and Aziziyah has been used, partly because these data were most readily available, and partly because the records were taken only a few kilometres distant from the areas selected for detailed study. Comprehensive temperature and humidity records are not available for these areas themselves.

Temperatures are only important to us in so far as they affect agriculture, and constrain agricultural activity.

Temperatures are high enough at the coast and inland to cause very high transpiration, which is the plant process by which plant surfaces exposed to sunlight are prevented from becoming overheated. Transpiration is a heat regulator. But there is no detailed evidence for Libya that high temperature itself prevents the cultivation of summer crops normally found in such areas, although since temperatures are often over 30°C the growth rates are decreased. Thornthwaite,[1] quoting Lehenbauer,[2] has shown for maize (a summer crop in Libya) how growth rates can be restricted. (Fig. 4.1.1). The optimum

Fig. 4.1.1.



Source : Lehenbauer P.A. Physiological Researches Vol. 1 1914 pp. 247-288.

°C.	v.
0	0.36
5	1.19
10	3.88
15	12.33
20	35.52
25	78.30
28	98.27
30	99.69
32	90.30
35	64.56
40	26.32
45	8.76
50	2.72
55	0.83
60	0.25

v = % of the optimum computed growth rate (optimum 29° - 32°C)

temperature for growth is 30°C, and this figure has been shown to be general for most plants.[1] The limiting minimum and maximum temperatures for growth vary, but the minimum is approximately 0°C and the maximum over 40°C. Plants can however survive higher and lower temperatures ; the olive tree for instance is not generally required, in Libya, to undergo the -8°C temperatures which limit its growth in the northern Mediterranean ; certainly not in the areas which we are considering. Maximum temperatures over 45°C at the coast and over 50°C in the Suwani bin Yadim areas cause growth to cease, and where the dry 'ghibli' wind is associated, the wilting point for most field crops is exceeded, except with the most careful irrigation. Such 'ghibli' conditions, if they occur at an inopportune period (such as soon after germination) can destroy large proportions of a season's fruit and field crops. It will be noted that relative humidity is extremely low during the period April to September at places 20 kilometres from the coast. (Appendix 2) The general water requirement by plants is therefore high, in all areas, but especially further from the coast, where the admirable design of plants for heat dissipation is constantly tested, and is sometimes found wanting in the extreme 'ghiblis'.

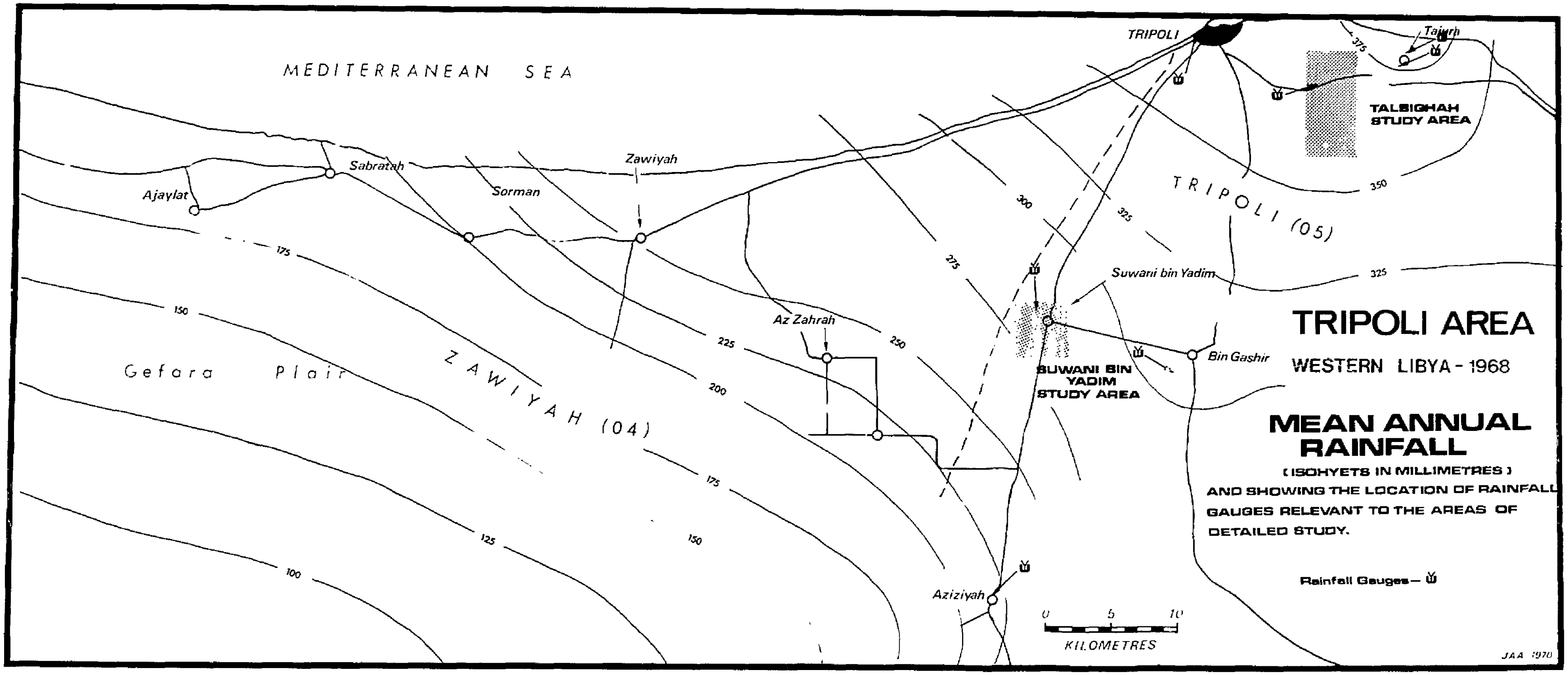
As with other Libyan climatic characteristics, the occurrences of the 'ghibli' winds vary in intensity and frequency. Records for the period 1928-1938[4] (Appendix 2) for some coastal stations and also for Aziziyah, 40 kilometres inland, show the greatest frequency to have been in spring and early summer. This is precisely the season when great damage can be done to the winter crop harvest, or to the young summer crops, recently germinated, such as tomatoes and groundnuts. Crops can only survive a severe April or May 'ghibli' with supplementary irrigation.

4.1.2 Rainfall

This background of high temperatures, low relative humidity as well as high rates of evaporation and transpiration, is important when considering the pattern of rainfall in coastal Libya.

Stations at which rainfall data are collected in Libya, are more numerous than those for temperature, and records are available for points within the areas of detailed study, as well as outside them, making it possible to draw generalised isohyet maps for the coastal area. (Fig. 4.1.2).

Rainfall is the most important factor in controlling the extent and yields from dry land crops, grown in the winter season in the areas being considered, and these dry land grain crops were sometimes the only crop in some areas. In others the same ground was irrigated



Source: Fantoli A. *Le Pioggie della Libia*, Roma,(1952), & Meteorological Records of the Department of Meteorology, Tripoli, (1952–1967).

FIG 4.1.2

in summer to produce another type of crop. Both patterns were found within the areas of detailed study.

Records of mean precipitation are misleading, as they would indicate that in both Talbighah and Suwani bin Yadim mean annual rainfall at 297 mm. and 244 mm. respectively,[3] is sufficient for dry land grain crops. Rainfall of 200 mm. is the minimum which will support barley, the most hardy grain ; rather more is required by wheat, the second Libyan grain crop.

Precipitation does vary considerably from year to year. The station in the Talbighah area shows that in the recent past (1960-1968), rainfall has varied from 223 mm. to 427 mm., and at Suwani bin Yadim, since 1954, rainfall has been as low as 111 mm. and as high as 484 mm. All rainfall data show totals for the September-August period, as the rainfall throughout the winter growing season is relevant to agriculture. (A January to December total would not be agriculturally significant.)

The distribution of rainfall within the rainy season is also very important. Germination of winter crops may be prevented if soil moisture is not replenished by rains in the September-November period. Ideally 100 mm. should fall in this period, and it can be seen (Appendix 2) that at Tripoli only in seven out of the 15 years between 1953 and 1968 had more than 100 mm. fallen between September and the end of November. For Suwani bin Yadim 100 mm. was recorded in only 3 out of 13 years (1955-1968).

Similarly a drought in the second half of the rainy season limits the harvest from winter crops. Precipitation of 100 mm. between January and March is minimum to maintain soil moisture during the period. Preferably it should be well distributed during this time. Rainfall data in Appendix 2 for Tripoli and Suwani bin Yadim show that Tripoli had 8 out of 16 January to March periods with sufficient rain (1953-1968), while Suwani bin Yadim had only 5 out of 13 (1955-1968). In Tripoli in 5 out of these 8 years, the rain was well distributed throughout the three months, while at Suwani bin Yadim in only 2 of the 5 years was the rain reasonably spread. Such records help to confirm the marginal character of Libyan dry land agriculture.

Table 4.1.3 provides similar evidence in a different form. By computing the standard deviations and coefficients of variability for Tripoli, and the inland station of Aziziyah it becomes clear that the degree of variability is very high, and very significant throughout the winter growing season, and especially at the beginning and end of this period, i.e. in September and October, and in March.

Further data which show the character of precipitation in coastal Libya are given in Tables 4.1.4, 4.1.5, 4.1.6, 4.1.7 and 4.1.8. In these tables the average distribution of rainfall throughout the year are shown as well as the intensity of the showers. The tables emphasise the variability of rainfall, and show that very heavy showers are possible. The damage normally associated with a landscape where vegetation is sparse and soils generally dry and friable is not, however, evident in the areas of detailed study, as there is little amplitude of relief. The Talbighah area rises from 10 metres in the north to only 80 metres in the south, and at Suwani bin Yadim there is no more than 20 metres range in elevation. Soil erosion is not a problem in these two areas, but it is a serious problem where deep wadis have developed in other parts of the Gefara Plain.

TABLE 4.1.3

RAINFALL

Monthly Standard Deviations for Tripoli and Aziziyah

millimetres.

		J	F	M	A	M	J	J	A	S	O	N	D
Tripoli	Mean (mm.)	72.0	38.1	28.9	8.9	4.7	1.6	0.6	0.4	10.5	31.9	69.7	87.3
	Standard Deviation (mm.)	42.9	25.7	45.8	9.4	6.2	2.3	2.5	1.2	19.2	34.4	59.0	65.8
(35 Years)	Coefficient of Variability. (S.D. % of Mean)	59	68	159	105	129	150	415	288	184	108	85	75
Aziziyah	Mean (mm.)	56.1	32.9	23.1	11.2	2.4	0.8	0.4	0.1	7.8	12.0	25.0	45.2
	Standard Deviation (mm.)	33.7	23.0	14.4	12.8	3.4	2.9	0.2	0.1	12.2	12.9	16.6	34.5
(14 Year)	Coefficient of Variability.	60	70	62	114	146	371	450	111	156	107	67	76

Source: Fantoli *Le Pioggie Della Libia* Rome 1952 with computation.

RAINFALL IN COASTAL LIBYA

WESTERN PROVINCES

TABLE 4.1.4

Distribution Throughout the Year - Per Cent

Tripoli & Aziziyah		
	Tripoli	Aziziyah
Sept-April	98%	98%
Sept-November	31	24
Dec-January	47	45
February-April	20	29

TABLE 4.1.5

Percentage of Rain by Month - Mean Monthly Figures

	S	O	N	D	J	F	M	A	M	J	J	A
Tripoli	3	10	18	27	20	11	6	3	1	-	-	-
Aziziyah	3	9	12	24	21	15	9	5	2	1	-	-

TABLE 4.1.6

Frequency of Rain Days

Tripoli

	S	O	N	D	J	F	M	A	M	J	J	A	Year
Rain Days	1.8	4.6	7.4	10.5	10.7	6.7	5.1	2.8	2.2	0.9	0.3	0.3	53.3
%	3.4	8.6	13.9	19.7	20.1	2.6	9.5	5.3	4.1	1.7	0.5	0.6	100

compare	Tripoli	53 rainy days.	7mm. per rainy day.
	Aziziyah	43.6 " "	5mm. " " "

Source: 1. Fantoli, A. Le pioggie della Libia Roma 1952.
2. Department of Meteorology, Ministry of Communications, Tripoli.

RAINFALL IN COASTAL LIBYA

WESTERN PROVINCES

(cont.)

TABLE 4.1.7

Tripoli and Aziziyah					
	% of Rainy Days			Average Rainy Days Per Year	Average Rain Per Rainy Day
	mm. in shower				
	0.1-5.0	5.0-20.0	7.20	N.°	mm.
Tripoli	64.0%	27.4%	8.7%	53.3	7
Aziziyah	71.0%	24.0%	5.0%	43.6	5

TABLE 4.1.8

	Maximum Rainfall in 24 Hours (mm.) Tripoli											
	S	O	N	D	J	F	M	A	M	J	J	A
Tripoli	81	86	130	122	72	125	152	50	20	-	-	28.1

Source : Fantoli, A. Le pioggie della Libia Roma 1952.

4.1.3 Evapotranspiration

No experiments establishing actual evaporation, or evapotranspiration rates have been carried out in Libya, and so data from work completed in Malta and Egypt, where climatic regimes are similar, have been quoted.

Despite the reservations of many agriculturalists concerning calculated evapotranspiration rates,[5] these rates do assist in the assessment of crop water requirements. The reason for the scepticism arises from the inability to attribute the effects of the many additional variables. It has been shown by Penman[6] and others that this is a complex problem in which the completeness or otherwise of the canopy of vegetation is very important, as is the stage of maturation of the crop and the degree of depletion of water from the surface portion of the soil.[7]

It is also important to note that evapotranspiration from areas with crops is much higher than the evaporation from bare soil. Some experiments have shown it to be eight times higher.[8]

Later experiments of Penman[9] (1949) led him to the conclusion that as long as soils remain moist and well covered by growing vegetation, the evapotranspiration is controlled by environmental conditions, and is independent of the nature and yield of the vegetation. By 1956 Penman had concluded that "the maintenance of the maximum transpiration rate is a necessary condition for the maintenance of maximum growth rate."

These preliminary general comments have been made to make the treatment of irrigation in later sections more coherent.

It has already been indicated that the necessary equipment and data are not available in Libya to properly quantify the extent of evaporation, and evapotranspiration. Meanwhile Stanhill[10] has shown Penman's meteorological formula for computing potential evapotranspiration to provide the best estimate. Also Mitchell,[11] in Malta, found that Penman's formula for computing potential evaporation gave results which corresponded closely with his own from field experiments at Hal Far. Both methods at Hal Far gave evaporation rates of approximately 25 mm. in January, and of 200 mm. in August. Hal Far has a higher mean annual rainfall than Tripoli, at 520 mm. compared with 362 mm. and is somewhat cooler. Thus the figures shown in TABLE 4.1.9 show a more favourable situation than can exist in most years in coastal Libya.

TABLE 4.1.9

POTENTIAL EVAPO-TRANSPIRATION AT HAL FAR (MALTA) BY PENMAN'S FORMULA, AND MEAN MONTHLY RAINFALL AT SIDI MESRI (MM.) (LIBYA)

	S	O	V	D	J	F	M	A	M	J	J	A	TOTAL FOR YEAR
POTENTIAL EVAPO-TRANSPIRATION AT HAL FAR	173	122	137	79	64	76	84	99	160	165	178	211	1547
RAINFALL (mm.) - MEAN MONTHLY - TRIPOLI	10.5	31.9	69.7	87.3	72.0	38.1	28.9	8.9	4.7	1.6	0.6	0.4	365

SOURCE : MITCHELL, P.K. The moisture characteristics of the Maltese climate

NOTE. HAL FAR IS 300 KM.NORTH OF TRIPOLI, SLIGHTLY MORE HUMID AND COOLER

Some notions of the resulting soil water balance are shown in Appendix 2.8, making some assumptions about the 'field capacity' of the soil. Depending upon this last assumption, soil moisture deficits range from 440 mm. for the year for a soil capacity of 64 mm., to 1095 mm. for a soil capacity of 155 mm.

The Concept of Evapotranspiration

The concept of evapotranspiration has been said to have served a very useful purpose but that it is of limited use in arid zone agriculture.[12] The notion is useful, however, in highlighting a number of problems of the Libyan farmer in his rain-deprived environment.

Thornthwaite's definition runs that potential evapotranspiration is the water loss which will occur if at no time there is a deficiency of water in the soil for the use of vegetation. He later pointed out[13] that it was necessary to standardize the recordings so that the albedo of the evaporating surface be standard, that the rate of evaportranspiration must not be influenced by the advection of moist or dry air, and that the ratio of energy utilized in evaporation to that in heating the air must remain essentially constant.

In 1956 Penman drew important conclusions about potential evapotranspiration rates from a review of the physics of the evaporation process. He concluded that "for complete crop covers of different plants, having the same reflection coefficient, the potential transpiration rate is the same, irrespective of plant or soil type. Secondly, this rate of water loss is determined by prevailing weather, and thirdly the rate of loss cannot exceed the evaporation from an open water surface exposed to the same weather." Penman's fourth conclusion is also important in the application of the concept of evapotranspiration to irrigation, in that he claimed that "the maintenance of the maximum transpiration rate is a necessary condition for the maintenance of maximum growth rate."

The concept has been most widely applied in the calculation of crop water requirements and irrigation control, although in arid zones (and Libya can be included in this definition) high potential and low actual rates of water loss introduce great difficulties into meteorological methods of calculating water requirements for irrigated agriculture. Crowe[14] emphasised the alteration in meteorological conditions which occurs in arid regions when potential conditions actually exist. Also crop growth appears to be more sensitive to soil moisture conditions when intense evaporation is taking place, making water requirements for irrigation more critical under arid conditions.[15] A further difficulty in the use of the concept is that if crop, "soil moisture and climatic factors are defined with sufficient precision to satisfy the definitions of potential evapotranspiration, then the concept ceases to have much relevance to conditions actually existing in the normal agricultural practice of arid zones."[16]

Stanhill goes on to show that of the formulae, Penman's meteorological formula gives the most accurate estimate of potential evapotranspiration. But most important he concludes that the size of the irrigated area and the crop height cause considerable variations in the rates of potential evapotranspiration, so that in most irrigated areas potential evapotranspiration can only be considered independent of crop characteristics when the area receiving daily irrigation is very large.

Evapotranspiration in Coastal Libya

Referring again to Table 4.1.9, with the conclusions of Penman in mind, as well as the reservations of Stanhill, the problems of the Libyan farmer become obvious. It is the fourth conclusion of Penman which is most important, namely that the maintenance of the maximum transpiration rate for the prevailing weather conditions is essential for the maintenance of maximum growth.

Table 4.1.9 shows that only in December and January is mean monthly rainfall in excess of the potential evapotranspiration rate of Malta's Hal Far, which is according to mean monthly figures better favoured than Sidi Mesri in respect of the variables determining evapotranspiration. It should be remembered that not all precipitation is available to the plant or for the maintenance of soil moisture. A proportion may reach the groundwater reservoir. Stewart[17] suggests 4.5% takes this course, and estimated that a further 4.5% was lost through surface run-off to the sea etc. Finally he estimated that 78% returned to the atmosphere by 'direct evaporation from the soil to the air,' and 14% only was transpired through plants. Additional data were assembled by the French consultants, C.O.T.H.A.[18] who calculated the evaporation at Tripoli to be 990 mm. per year, and at Aziziyah 1080 mm. These are lower estimates than those of Mitchell, but they still indicate that evaporation proceeds each year at rates between three to five times that of precipitation, and Thornthwaite's theoretical scale of aridity places Sidi Mesri, and therefore almost all of the study area in the 'arid' category.

It is clear therefore that there can be periods of soil moisture deficiency at any period of the year, even during the months when rainfall is highest. Conditions will be unfavourable for the maximum growth of the plant between the months of March and November each year. Growth can be inhibited, and under the severest conditions terminated, when transpiration becomes impossible through moisture deficiency.

Two conclusions can be deduced from the preceding discussion. First the Libyan farmer can only anticipate extremely poor yields from non-irrigated crops. Official agricultural statistics confirm poor yields to be the rule.[19] Secondly an improved agricultural performance depends upon the improvement and extension of the use of underground water. In Chapter 6 it will be proved that this basic resource is limited and was being severely 'overused'.

4.1.4 CROP ECOLOGY

Influence of Temperature on Crop Growth

Temperature greatly affects crop growth. Within the range 0°C to 35°C approximately, an increase of 10°C nearly doubles the rate of growth.[20] Above 35°C rates of growth decrease rapidly and finally cease.

Crops are by no means identical in their optimum requirements. An approximate idea of the temperature requirements of different crops can be obtained from the following table, which shows the minimum, optimum and maximum temperatures for some seedlings.

TABLE 4.1.10

Cardinal temperature points for growth of seedlings °C

(Minimum and maximum indicate temperatures at which growth stops.)

Crop	Maximum	Minimum	Maximum
Barley, oats, wheat	0-5	25-31	31-37
Maize/Corn	5-10	37-44	44-50
Pumpkin	10-15	37-44	44-50
Melon, cucumber	15-18	31-37	44-50

Source : Haberlardt. (quoted by Maximov in Plant physiology 1947)

It is important to note that beyond the optimum the injurious influence of high temperatures quickly becomes apparent, also that the optimum temperature for growth may not be the most favourable for the general development of the plant. Crop hardiness and general health may be impaired by excessively rapid development, and the temperature optimum for growth varies during the period of development. Generally in the earlier stages of development the optimum is at a lower point than during the later stages.

Relating this ecological evidence to data from the coastal areas of Libya it can be seen that temperatures are generally favourable for winter crops in Libya, while summer crops may be severely damaged by high summer temperatures, especially as these are almost always associated with low relative humidity, and especially if 'ghibli' conditions occur. On the other hand the high temperature regime does have the advantage of promoting rapid crop development. Temperatures are often close to the optimum, but the damaging effects of the frequent occurrence of temperatures close to the maximum far outweigh the advantage of rapid development, especially in the case of non-irrigated crops. Table 4.1.11 shows the general relationship of minimum, optimum and maximum temperatures with meteorological records for coastal and inland stations in Libya. This comparison seems to show how close to the maximum are summer conditions, especially further from the coast. It should be remembered that these are only mean maximum figures. On occasions maximum temperatures above the mean can occur for a number of days consecutively (e.g. May 1968). When temperatures from 35° - 40°C are prolonged there is a disadvantageous relationship between respiration and photosynthesis, the latter having a low optimum as compared with respiration. At high temperatures, the expenditure of organic substance in the process of respiration exceeds its synthesis, and the plant is gradually depleted of its carbohydrates and begins to 'starve'.

TABLE 4.1.11

A COMPARISON OF MINIMUM, OPTIMUM AND MAXIMUM TEMPERATURES FOR SOME SELECTED CROPS, WITH MEAN MINIMUM, MEAN AND MEAN MAXIMUM TEMPERATURES IN COASTAL LIBYA. °C

				TRIPOLI				AIRPORT/B.GASHIR				AZIZIYAH			
				Coldest Month		Hottest Month		Coldest Month		Hottest Month		Coldest Month		Hottest Month	
	Min	Opt.	Max.	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max	M.Min	Mean	Mean	M.Max
BARLEY, OATS, WHEAT	0-5	25-31	31-37	7.6	11.8	26.2	30.8	5.3	11.7	28.0	36.9	5.4	11.5	28.8	37.6
MAIZE/CORN	5-10	37-44	44-50												
PUMPKIN	10-15	37-44	44-50												
MELON, CUCUMBER	15-18	31-37	44-50												

Sources : Crop Data - Harbelardt (quoted by Maximov), Plant physiology 1947.

Meteorological Data - Dept. of Met. Ministry of Communications Tripoli Libya.

This last characteristic is important in crops such as winter grain and vegetables in Libya, which are weakened by relatively high temperatures, and yields reduced. For instance it is not uncommon for temperatures to reach 30°C in February, March and April, when winter grain may be ripening. The date of harvesting varies considerably however, as sowing is partly dependent on the date of the first major rainfall, which may be in October, November or December. Thus the effect of sudden increases in temperature during the early months of the year, may or may not be significant.

High temperatures however are not so important as moisture deficiency in inhibiting plant growth. The sparce covering of vegetation and crops in northern Libya arises from water deficiency. It is water deficiency which prevents unimpeded transpiration and the consequent necessary reduction in leaf temperature. But it should be noted that plants transpiring intensely at very high temperatures are less subject to overheating, than if transpiring at a lower rate, at lower temperatures, in humid conditions. Thus dry heat is more easily endured, except when associated with extremely hot dry winds, such as the 'ghibli', when crops may be severely injured in a short time.

Influence on Crop Growth of the Degree of Saturation of the Plant with Water

Various vital plant processes require a different degree of saturation with water, the greatest amount being necessary for the process of growth. For example if seeds are not given water sufficient for their complete saturation they will not grow ; quantities of water up to half this amount will cause some processes to commence, but growth will not take place. Much water is required for all functions connected with the formation of new masses of living substance, and also for respiration and digestive processes.

The availability of soil moisture is more important at periods of rapid growth (e.g. in grain crops during the pre-'shooting' stage, and in trees and shrubs during the formation of new shoots and fruit). It is normal in the late stages of development that the crop will need less water for growth, but in Libya in the increasingly hot and dry conditions of spring and summer, the requirement for transpiration and therefore for water increases. In general, with a deficiency of water, the stage of elongation terminates too early, which leads to the production of small cells and stunted plants. The same result is obtained when water loss is too rapid. Strongly evaporating leaves may lose water faster than it is delivered from the soil ; water is withdrawn from the growing organs, which again leads to the formation of small cells and a reduced plant size.

Water Stress in Crops

It has been shown that water stress affects crop growth in many ways. Plants and plant organs subjected to water stress are almost always smaller than their equivalents not subjected to stress. Growth is affected so that tissues have thicker and more heavily 'lignified' cell walls, and leaves become thicker and smaller in area. Severe water stress also causes premature closure of stomatas, reduction in photosynthesis, disturbances in the rate of respiration, and changes in the course of bio-chemical processes such as carbohydrate and nitrogen metabolism.

Water balance in crops depends upon the relative rates of water absorption and water loss, and a water-deficit can be caused by excessive water loss or by reduced absorption, or by a combination of the two. On bright sunny days, when transpiration is rapid, water absorption often lags behind transpiration because of root resistance. Absorption lag can cause wilting even in soils near field capacity.

Even in winter therefore, in northern Libya, where the hours of sunshine are long, and temperatures rise to high mean levels, transpiration rates are high and water loss occurs at a rate in excess of water absorption.[21]

A water deficit occurring mainly in the afternoon represents quite a normal phenomenon and is not injurious. This condition is termed temporary wilting and occurs when the water balance has been significantly disturbed. This may be temporary, as the water deficit decreases with lower insolation and temperatures in the evening. Temporary wilting is not very injurious, but yields are reduced as growth is impaired through interference with photosynthesis in the wilted condition, and extremely low yields of dry land crops in Libya can be largely attributed to this problem.

Permanent wilting occurs when the soil moisture cannot redress the crop's water deficiency. Root hairs are damaged, and take time to recover so that there is a delay in the return to full water absorption. Permanent wilting is very serious and also affects yields generally, and particularly the quality of the grain in grain crops. It also gives rise to the additional problem of irregular ripening.

4.2 Underground Water

4.2.1 Geology and a Description of the Aquifers

The geology of the Gefara plain of the Western Provinces has not been studied in sufficient detail to allow a full description nor a detailed treatment of the geology and hydrogeology of the study area or the case study areas of Talbighah and Suwani bin Yadim. Geology can only be treated, therefore, in broad terms.

Three zones have been identified[22] in the area around Tripoli, where the sedimentary formations dip gently to the sea in the north. Figure 4.2.1 attempts to show a simplified version of the disposition of the aquifers , and related geology.

The upper zone is thought to be largely Pleistocene and recent in age, and consists of dune sand, sand, limestone and minor clay. An intermediate zone described by Desio as being of late and middle Miocene age, consists of limestones with underlying clays. The sands, sandstones and associated limestone of the lowest zone are of early Miocene age.

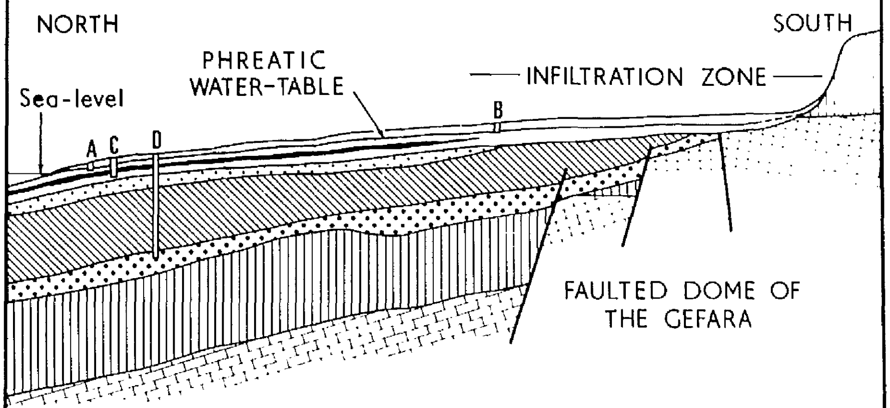
Cederstrom[23] indicated that the geological age was of small importance, and draws attention rather to the hydrological characteristics, more significant in his work, and in this thesis.

The upper zone contains what is commonly known as the phreatic water-table. This lies in the thin beds of limestone and sandstone, with minor sand and clay. These beds lying beneath the unconsolidated sands yield fair to copious supplies of water (i.e. over 100 m^3 per hour in some cases).[24] The zone containing the phreatic water varies in thickness, but Cederstrom generalises that wells sometimes up to 40 metres deep derive their water from this zone. Yields of up to 20 m^3/hour can be obtained with pumping, although in the past it was in the traditional gardens that the phreatic water-table was exploited, and here the old 'dalu' method of raising water yielded only 3 to 8 m^3/hour.

The second aquifer is found 20-25 metres below the first water-table in what we have called the intermediate zone. Its depth below the surface varies, being found at approximately 30 metres in the Talbighah area. At Suwani bin Yadim it is difficult to distinguish between the first and second aquifers as the 'Tirrenian' clay is thin or absent[25] (see Fig. 4.2.1.). This is a common feature throughout the Gefara.

FIG 4.2.1

AQUIFERS BENEATH THE GEFARA PLAIN



	QUATERNARY & RECENT MATERIAL - AEOLIAN SANDS-ALLUVIUM-FANS-CONCRETIONARY LAYERS	FIRST & SECOND AQUIFERS
	TIRRENIAN CLAY LAYER	IMPERVIOUS SEPARATES THE ABOVE
	MIOCENE LIMESTONE	MINOR AQUIFER
	MIOCENE CLAYS & MARLS	IMPERVIOUS CAP
	MIOCENE SANDS	CHIEF ARTESIAN AQUIFER
	CRETACEOUS	?
	TRIASSIC	?

Types of wells: A LITTORAL PHREATIC; C DEEP QUATERNARY; B INNER GEFARAN PHREATIC; D ARTESIAN

AFTER DESIO·CHIESA·VIALI·LIPPARINI·ARCHAMBAULT·HILL

There is danger in simplifying the hydrological basis, and it has been recorded[26] that the first and second aquifers should be regarded as a single-water table flowing in strata of varying permeability with non-continuous impermeable strata between them. There are good examples of these 'non-continuous' characteristics in the Talbighah area where in 1968 wells located less than 500 metres, and sometimes less than 100 metres apart, reached water at significantly different levels, and yielded at very different rates. The new well (constructed in 1968) at the north east corner of the former Gargour estate (Fig. 4.2.2) is located 500 metres from well 361 and 350 metres from well 398. The new well yielded at over 150 m^3/hour, well number 361 at only 30 m^3/ hour, and 398 at 4 m^3/hour.* Data for a group of wells located within 200 metres (well numbers 375 to 382) (Fig. 4.2.2) and shown on the table below indicate the variation in the level of the water-table, as well as the yield of the wells over an area only 300 metres square. These wells have been carefully recorded as they were a major source for the former United States Air Force base at Mellahah.

The deepest aquifers are found in the lowest zone of the Miocene in sands, gravels, and sandstones, and associated limestone, (Fig. 4.2.1.). The upper surface of this zone is at 450 metres near the coast, but does reach the surface where the Cretaceous outcrops at points inland on the Gefara.

This arrangement of the strata causes most of the wells penetrating these deep aquifers to be artesian. Heads of water of 63 metres above sea-level[27] are average, and seem to confirm that the source of the artesian water is precipitation on the Jabal. This is also the opinion of Desio.

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* It should be noted that part of the difference in yield resulted from the length of use of the older wells and their consequent 'clogging'.

TABLE 4.2.1

Elevations and Yields

of Wells Near Talbighah

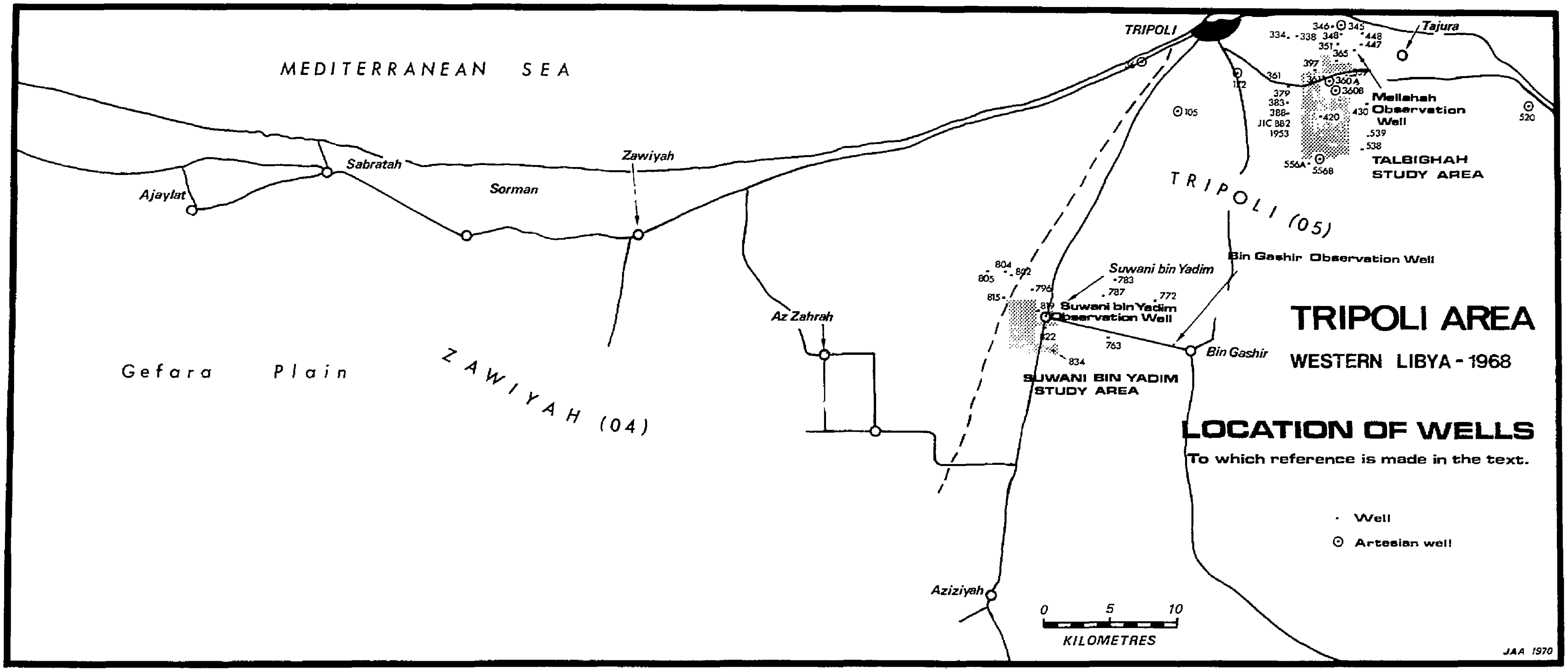
Well No.	Elevation at surface (metres)	Depth (metres)	Water Level (metres below surface)	Absolute height of water above sea level (metres)	Yield m^3/hour
375	21.3	31	18.1	3.2	57
376	26.6	37	23.5	3.1	40
377	21.7	30	17.7	3.0	55
378	24.4	34	18.5	5.9	21
379	22.3	30	17.5	5.8	45
380	25.5	32	16.0	9.5	21
381	24.2	54	18.1	4.1	37
382	23.3	30	16.5	6.8	40

Source : Cederstrom and Bertaiola,

Tables of Well Records in the Tripoli Area

Table 6, p.62, 1960

Note : Similar pumping equipment was used in all the above wells



Source: Cederstrom D.J. & Bertaiola M. *Ground Water Resources in the Tripoli Area*, USOM, Tripoli, 1960, Figs 10,11,13.

FIG 4.22

Yields from artesian wells were good in quantity, though not in quality. Upwards of 300 m^3/hour had been recorded[28] especially in the eastern part of the Gefara, in which the areas of detailed study were located.

4.2.2 Recharge and Depletion of the Aquifers

Aquifers can be recharged through rainfall percolating from above, or through underground water flowing in from other areas. It has been shown that in general the aquifers dip to the sea as also does the surface (Fig. 4.2.1.). Water therefore flows underground from the south to the north, except where the equilibrium between sea and fresh water has been upset, through excessive pumping near the coast, and sea water intrusion has resulted.

Recharge from rainfall is probably small in the coastal areas, compared with the water which flows in underground from the south. Measurements taken by the author in October 1968, immediately before and after a number of heavy storms, when 96 mm. of rain fell in Talbighah in 10 days, show that the resulting rise in the level of water in wells was only in the order of 20-30 mm., after one week. A week can be regarded as a reasonable period upon which to make deductions, as the transmissibility (i.e. the rate at which water can move through the overburden of rock or soil) of the superficial deposits, into which the sampled wells have been sunk, was good. Other data in the area is available concerning the lithologies of well numbers 383, 361, 360B and 359 (Appendix B) ; these are close to wells 365, 397 and 420, which are being discussed in connection with the question of re-charge to demonstrate the transmissible character of superficial deposits in the Talbighah case study area. It will be seen that they consist mainly of limestones, sandy marls, sandy clay and clay.

TABLE 4.2.2

Rainfall and Under-Ground Water-Level

Records for the Talbighah area - October 1968.

DATE October 1968	(Gauge at North end of Gargour Farm.-Fig.4.2.2)	WATER LEVEL (Metres below surface)			
		Well No.	365	397	420
	mm. of rain.	Km. from Rain Gauge	0.6 km.	1.0 km.	2.5 km.
1st-19th	0		6.59 m	16.47 m	26.49 m
20	22.0				
21	30.5				
22	36.0				
23	5.0				
24	2.5		6.41	-	26.49
25	0		-	16.21	-
26	0				
27	0		6.31	16.16	26.37
28	0				
29	0		-	-	26.33
Total Rain	96.0 mm	Rise in Water mm	28	31	16

N.B. All well measurements were taken between 6.30 a.m. and 7.00 a.m. before the pumps were switched on for the day.

The 20-30 mm. rise in the level of water in the wells represents 20-30 mm. of saturated aquifer, and since the porosity of rocks can range from near zero to 50 per cent. (e.g. limestone holds 1-10% of water when saturated, sandstone 10-20%, soil 50-60%)[29] it is likely that this 20-30 mm. represents between 5 and 10 mm. of real recharge, or less than 10% of the precipitation.

Well number 420 was deeper than the other wells and predictably there was a lag in the rise of the water, of at least five days.

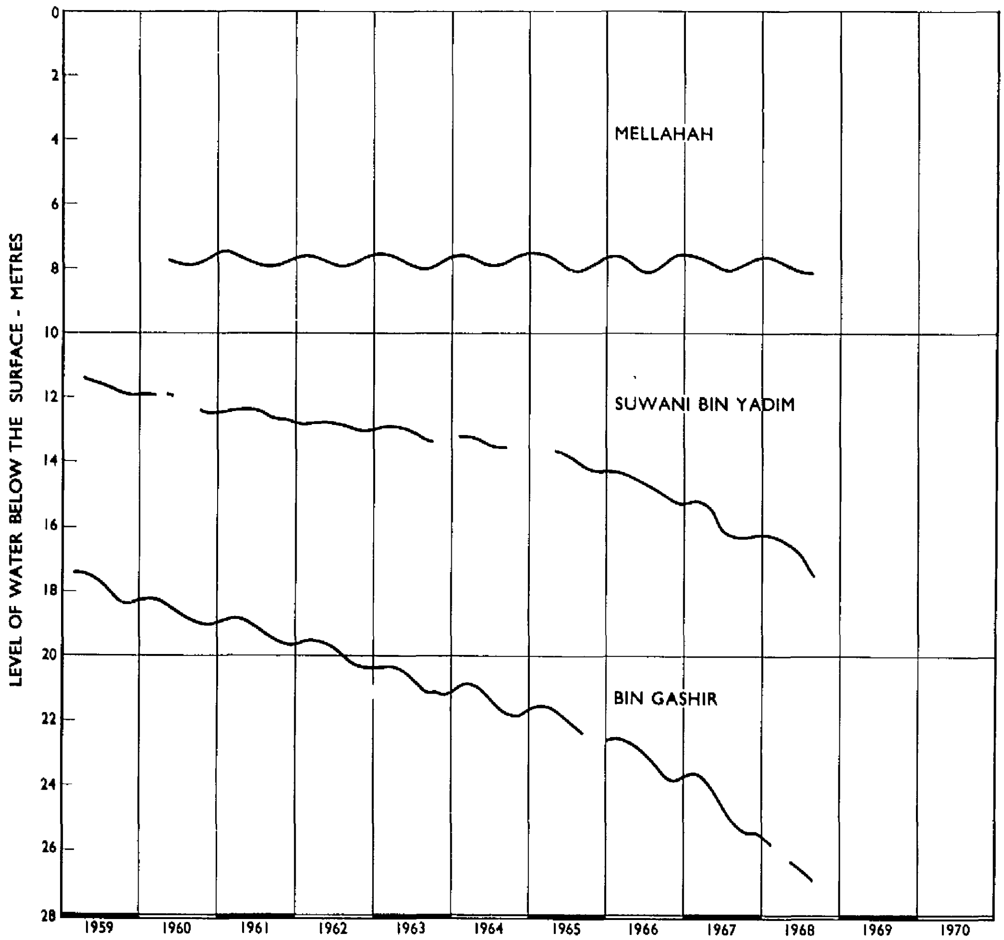
Readings were not continued for a longer period as the effect of recharge from underground water from outside the immediate locality would have become increasingly significant, and would have masked the effect of the local storm.

The time when these readings were taken also happens to mark the beginning of the season when water levels recover to heights close to those of the previous rainy season. It will be my purpose in another part of the thesis (Chapter 6.1) to demonstrate that there has been a serious and continuing decline in water levels in the study areas. The general situation is shown in Figure 4.2.3. It is clear from this diagram that water levels were declining at an increasing rate in areas 20 km from the coast (Suwani Bin Yadim and Ben Gashir), but the declines, even in wells within two kilometres of the coast were also very significant. Considerable effort has been expended on fieldwork in connection with this thesis in carrying out survey and photogrammetric work to fix the heights of wells located close to the sea (i.e. within six kilometres), so that the absolute height of the water in the wells above sea-level could be determined. As a result it can be shown that some wells were being pumped to below sea level during the dry summer season. This is a dangerous practice in terms of the threat of sea water intrusion.

FIG 4.2.3

WATER LEVELS IN WELLS
IN THE WESTERN PROVINCE

MELLAHAH, BIN GASHIR, SUWANI BIN YADIM



SOURCE :- Ministry of Agriculture, Soil & Water Conservation Department.

Stevens water level recorder in all three wells providing almost continuous records.

Such details will be elaborated and evidence set out in Chapter 6.1 to show that the second aquifer has been dangerously depleted, and that a high proportion of water extracted is being drawn from storage.

Unfortunately little work has been done in respect of the deeper artesian aquifers since the 1930s. Oil company surveys with other priorities in mind have yielded a small amount of evidence which confirms the Italian experience that almost all the deep aquifers are unusable because of their poor quality.

Also very little has been published which would allow one to pronounce upon the recharge and depletion of deep aquifers. Desio[30] insisted that the artesian aquifers were recharged by rainfall which fell on the Jabal Nafusah, and on the southern part of the Gefara. Certainly the dip in the strata from the south to the north explains the 'head' which most of the deep wells possess. One well close to the middle of the Talbighah area, and some five kilometres from the coast, flows constantly, but is unusable as its water is useless for agriculture.

4.2.3 Quality of Underground Water

Rather more work has been carried out in respect of water quality. Data on water quality were collected in 1958-60 by Cederstrom and Bertaiola for wells throughout the coastal area, and results relevant to the two case study areas are shown in Appendix 4.

In general water from the phreatic and second aquifers yield good quality water, both for domestic use and for agriculture. This is not everywhere true, in coastal Libya, as sea water intrusion has occurred in many places, especially to the west beyond Tripoli, where wells at Zawiyah were recorded by Cederstrom and Hill as pumping contaminated water. At Sabratah also, salinity is a problem, and further east at Zuwarah. Immediately to the north of the Talbighah case study area wells close to the sea were pumping undrinkable water in 1968, although it was still usable for irrigation. An awareness of the situation led to the shift to the south for sources of water supply for the air-force base. Much water was being pumped from the group of wells immediately to the west of the Talbighah field area (Well numbers. 375-383) (Fig. 4.2.2.) Also to the east of the area well numbers 430 and 431 were important producers. Both were located between 5 and 6 kilometres from the sea, and at this distance from the coast, certainly for the foreseeable future, safely located with regard to deterioration in quality through contamination by sea water.

But apart from this special danger of salt water contamination which exists for coastal wells, water drawn from wells other than deep artesian aquifers is satisfactory for irrigation, and almost everywhere for human consumption. This is certainly the case in both areas of detailed study, Talbighah and Suwani bin Yadim.

The water quality data shown in Appendix 4, indicates that water in the upper aquifers, which supplied all the irrigation water for the field areas, had a dissolved solids content (parts per million (ppm)) and a chloride content, which were everywhere at a level suitable for crop irrigation. Well 361 (Fig.4.2.2) had a very low chloride content at 48 ppm, and dissolved solids were shown as 330 ppm (Appendix 4). 500 ppm of dissolved solids is generally regarded as the highest level acceptable for human consumption. Well 361 was only 21 metres deep however ; but well 383 gives evidence for a well 62 metres deep. Both wells are at a similar elevation. The equivalent figures for the deeper well were 53 ppm for chloride content and 335 for dissolved solids, in other words not significantly different from the shallower well 361, and confirming the adequate quality of the upper aquifers.

Well 359, 28 metres deep, may appear to give conflicting evidence, with chloride at 596 ppm and dissolved solids at 2,394 ppm. These high figures are explained by the 'leaking' of the artesian well close by number 360A (327 metres deep), which shows chloride at 1060 ppm and dissolved solids at 2,620 ppm.

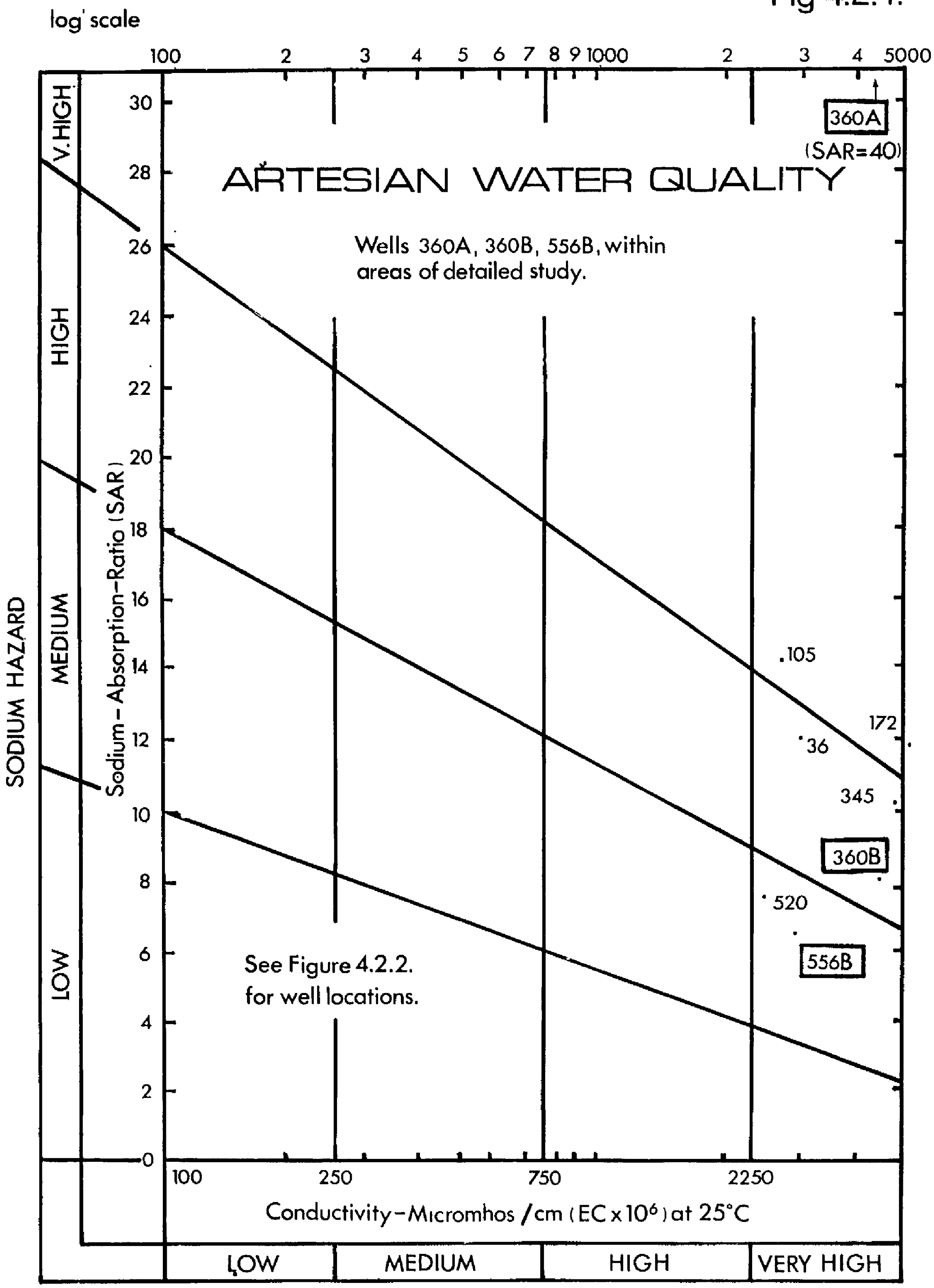
In the southern case study area, Suwani bin Yadim, wells in the study area itself produce satisfactory water. For well 834 (Fig. 4.2.2.) chloride read at 386 ppm and dissolved solids at 1414 ppm. Although less satisfactory than the water in Talbighah, the water was still usable. Chloride levels were lower in three other relevant wells, numbers, 763, 787 and 796, where chloride read at 99 ppm, 163 ppm and 319 ppm. Dissolved solids were significantly lower at wells 763 and 787 at 525 and 478 ppm respectively, although at a level similar to well 834 in the case of well 796 (1420 ppm).

Water from the artesian aquifer has been shown to be unusable even for agriculture, unless such water was treated or mixed with other water of better quality. Italian sources as well as more recent work are shown in Appendix 4. The criteria defining agriculturally usable water, i.e. chloride and dissolved solids content, are nowhere met, and other definitions of high mineralisation, sulphate and sodium content are often exceeded. Figure 4.2.4 shows that all the artesian water tested by Cederstrom was classified as 'very high' in salinity, and the majority unsuitable for reasons of their sodium hazard.

Artesian water in coastal Libya would seem to be usable only if used in conjunction with better quality waters, either alternately or by mixing.

The dangers of contaminating the upper aquifers has already been touched on, and there was a good example of this type of contamination in the Talbighah area.

Fig 4.2.4.



SALINITY HAZARD
(U.S. Salinity Laboratory diagram)

Source: Cederstrom D.J. & Bertaiola M., Ground Water Resources of the Tripoli Area, USOM, Tripoli, 1960, p.158.

Despite some Italian enthusiasm concerning artesian sources,[31] for example Desio claimed in 1940 that many artesian wells produced water suitable for agriculture, small progress was made in the development of these resources. The Italian authorities were also cautious about the rate of use of artesian wells, and ensured that they were sited two kilometres apart in the direction of underground flow (south to north on the Gefara), and four kilometres apart in the direction at right angles to this.

4.2.4 Water conservation

The Italian authorities were aware of the dangers of seriously depleting the underground waters of the country. Their regulations concerning water-use were not limited to the deep artesian water. The distances between all wells were limited, but possibly more important areas now being intensively irrigated by Libyan farmers were not conceived by the Italian government as suitable for other than dry farming.

The Libyan water law was not being administered in 1968 so that the digging of wells and the rate of extraction was not regulated. The increase in the rate of decline, quite clear in Figure 4.2.3 from 1964 onwards, can be related to the installation of new and additional pumping equipment following the inflow of oil revenues into the agricultural sector. Trade statistics show rapid increases in imports of manufactured items generally between 1961 and 1963, and agricultural equipment imports were in line with this general increase.[32]

4.3. Soils

Low rainfall, soil moisture deficiencies, and the extreme conditions which occur during the 'ghibli' winds are the main reason for low crop yields in the Western Provinces of Libya. However, the character of the soils of the Gefara also contributes to low yields.

Willimot described the soils of the Gefara as 'brown pedocalic regosols (calcareous), of the arid steppe type'.[33] There are alluvial soils in this part of Libya, and the northern part of the Talbighah area has soils of this type, but in general in the Gefara, and in the areas of detailed study, soils are aeolian, and of the 'intermediate type'. They are derived from the aeolian and marine sands of the interior, and the limestones, sandstones, marls and clays of the Jabal Nafusah.[34]

4.3.1 Mechanical Characteristics

Soils are sandy in character. In samples of Gefara soils analysed by Willimot[35] the main character was sandiness. The sand fraction ranged from 84 to 92 per cent in the nine samples, (international scale).

The Talbighah area has soils ranging from long cultivated loamy sands, in the traditional gardens in the north of the area, to soils which fall into the textural class of sand, in the dunes in the south.

Willimott's sample taken at Tajura closely represents the soils in the Libyan 'gardens' in the north of Talbighah. The analysis showed the following details :-

Coarse sand	0.4 %
Fine sand	87.0 %
Silt	4.2 %
Clay	8.4 %

This contrasts with a sample of sandy soil taken at Bianchi (Az Zahrah) which is similar to soils in the southern part of the Talbighah area, as well as those around Suwani bin Yadim. At Bianchi the analysis showed :-

Coarse sand	20.5 %
Fine sand	71.4 %
Silt	4.1 %
Clay	4.0 %

4.3.2 Drainage of Soils

The samples above, and observation in the field areas showed that both the 'loamy sand' and the 'sandy soils' were open, friable and free-draining. Percolation was rapid. Also there was rarely a strong development, and an undifferentiated character might extend to considerable depths.*

Because soils throughout the areas were well drained, there was little danger of the soils becoming salinised. Relatively saline irrigation water could be used without salinity problems developing, and only the heavily mineralised Gefara artesian waters were unusable. The low humus content also reduced the water-holding capacity of the soil and brought about high rates of leaching.

4.3.3 Chemical characteristics

Gefaran soils are alkaline, and the nitrogen content is low. The latter deficiency arises because of the very low accumulation of organic matter. Even soils cultivated for many years have a very low humus content.[36]

Work on the availability of plant nutrients is inadequate, but Willimott[37] assessed potassium to be adequate and phosphorous deficient, while suspecting that there were deficiencies in the trace elements of copper, zinc, iron and manganese.[38]

Analyses of the two relevant samples, those from Tajura and Bianchi, show the following chemical relationships :-

* Elsewhere in the Gefara a hard pan often develops, resulting from the accumulation of calcium bicarbonate, or a mixture of calcium bicarbonate and magnesium carbonate.

Soil analysis

	pH	Carbon %	Nitrogen %	C/N ratio	Organic matter	Sulphate	Nutrients K_2O	P_2O_5
Tajura	8.8	0.45	0.04	10.0	0.78	Trace	Low	Medium
Bianchi (Az Zahrah)	8.6	0.31	0.03	10.7	0.53	Nil	Low	Very Low

Source : Willimot, S. G. 'Soils of the Jefara' in Willimot and Clarke, Field Studies in Libya Durham 1960, p. 42-43.

4.3.4 Sand Dunes

The coastal belt of aeolian sands varies in width and does not extend into the areas of detailed study. Dunes do occur, however, in the south of the Talbighah area, and uncultivated parts of the Suwani bin Yadim area show a tendency to dune formation and movement. In this respect afforestation was important in many places, and especially in the southern part of the Talbighah area, where air photos demonstrate that former dunes were supporting young eucalyptus plantations by 1968.

CHAPTER 5.

THE DEVELOPMENT OF 'MODERN' FARMING

5.1 Development and Intensification of Farming on Ex-colonist Farms

The Tripoli Triangle was the area most affected by Italian colonisation of any in Libya. Figure 5.1 illustrates that the area of settled agriculture was increased over fourfold in the Tripoli Triangle, this being a much higher increase than for the Western Provinces generally. Rowland and Robb giving figures in 1947 for irrigated and non-irrigated farms estimated that Italian extensions had amounted to 118% and 130% respectively in Western Libya.

Table 5.1

Estimates of the Areas of Traditional and Italian Farming 1945

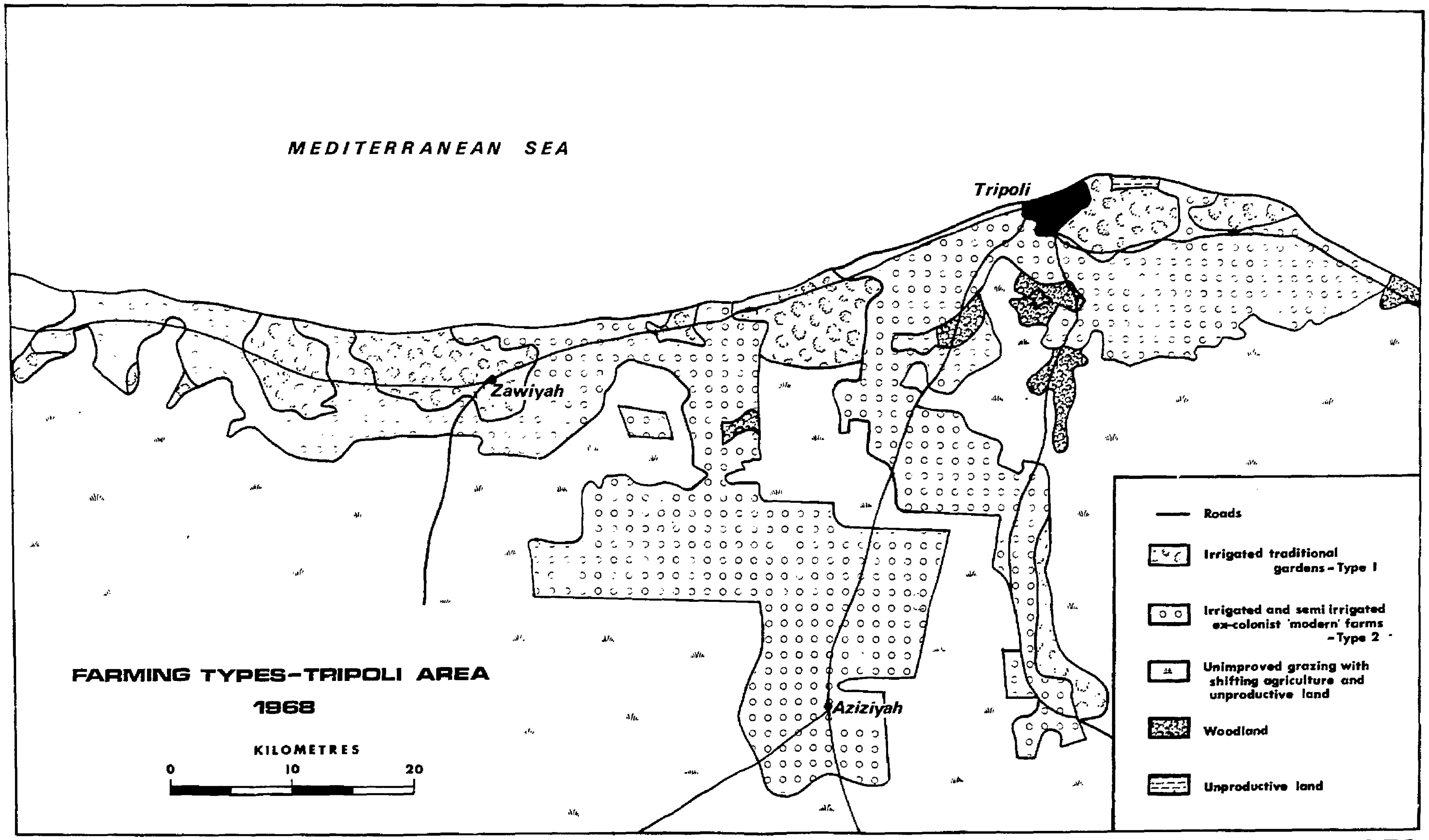
Hectares

	Traditional Gardens	Italian Farms
Irrigated	50,000	59,000
Non-Irrigated	127,000*	165,000+

* Excluding shifting agriculture
\+ Including 60,000 ha. of estates not provided with irrigation water.

Source: Rowland & Robb, Survey of Land Resources in Tripolitania, British Military Administration, Tripoli 1947 Land Use Map

The area selected for this study includes a very high proportion of the agriculture developed by Italian colonists in Libya and also, therefore, a large part of Libya's 'modern farming' sector as defined in this study. Fieldwork indicated that there were 21,000 hectares of irrigated and semi-irrigated traditional gardens and 89,000 hectares of irrigated and semi-irrigated modern farms in the study area (see Figure 5.1). These figures are lower than those which would derive from a simple measurement of the areas shown on Figure 5.1., as the scale of Figure 5.1 is too small to illustrate the very discontinuous character of Libyan farming. Also some account has been taken of those farms which have fallen out of use since the period when they were set up ; again these disused farms cannot be properly shown on such a small diagram.



Source: Joint Research Project Final Report, Vol. 2, Map 1.

FIG 5.1

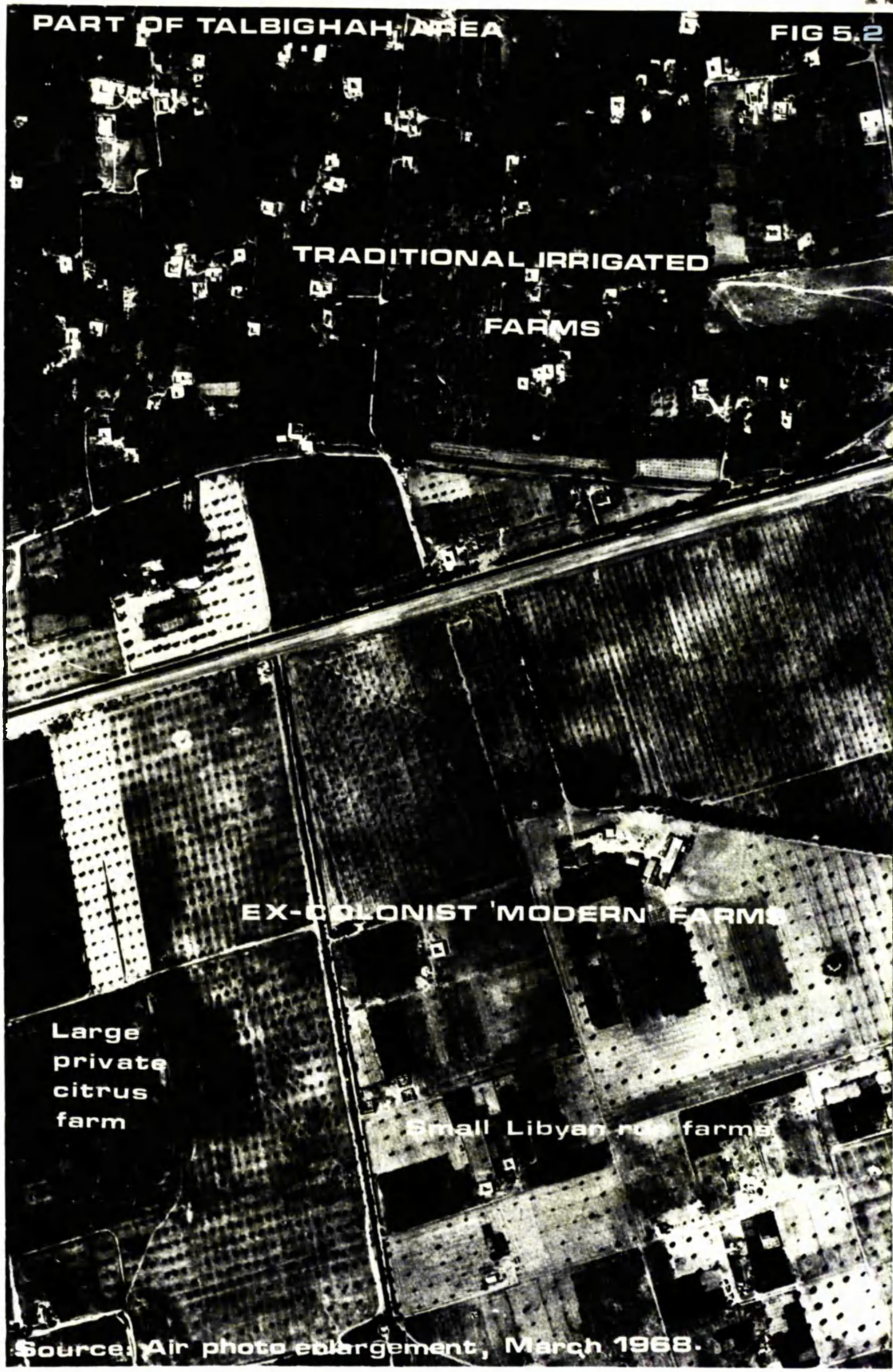
5.1.1 The Model : Traditional and 'Modern' Agriculture.

That traditional and modern agriculture could be easily distinguished, at least up to 1968, is readily illustrated by Figure 5.2. The air picture shows that size, farm layout and irrigation methods differed markedly in 1968 on the two types of farm, and earlier photography (1953) indicates the same situation.

Figure 5.1 shows a further characteristic of the distribution of the two types of farm. The traditional irrigated gardens were generally nearest the coast, where the aquifer was most accessible ; groundwater was rarely more than 10 metres from the surface, and was usually about six metres down. These areas farmed by traditional methods were already being farmed in 1911 and so the Italian colonists took over areas further from the coast where underground water was often much deeper, although rarely more than 20 metres down, at least in 1911. Private farmers settled first, taking over areas right up to the edge of the urban area in the early years of colonisation. In the late 1920s and in the 1930s, however, more difficult areas such as those around Az Zahrah were developed for government sponsored demographic settlement. A model, simplifying these developments is illustrated in Figure 5.3.

The main variables which permit a distinction to be drawn between traditional and modern farming are those of :-

1. farm size
2. fragmentation
3. type of irrigation
4. availability of electric power
5. number of permanent male workers employed
6. investment in rural housing and irrigation equipment.


PART OF TALBIGHAH AREA
FIG 5.2
TRADITIONAL IRRIGATED
FARMS
EX-COLONIST 'MODERN' FARMS
Large
private
citrus
farm
Small Libyan
farms
Source: Air photo enlargement, March 1968.

A Simplified Model of Farm Development in the Italian Period of Administration in the Tripoli Triangle. Fig 5.3.

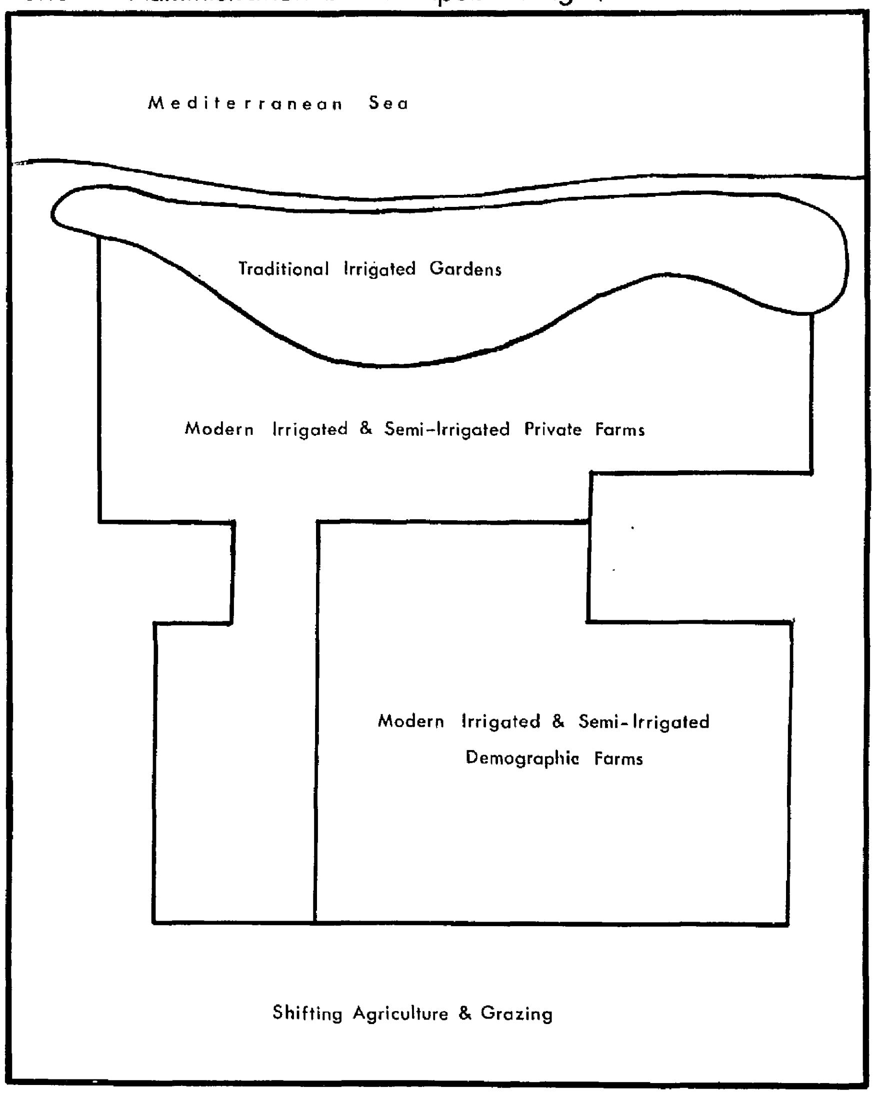


Table 5.2 shows how markedly the types of farm differed on the basis of the above variables in 1968. The differences shown are all statistically significant and when these and other variables were submitted to the Mann-Whitney and the Kolmogorov-Smirnov tests again the two farm types were confirmed as being significantly different.

Table 5.2

Variables which Distinguish Traditional and Modern Farms in Western Libya -1968

	Traditional	Modern
Farm Size - Hectares		
Mean	4.0	31.29
Standard Deviation	2.81	4.75
Under 5 ha.	63%	14%
Over 5 ha.	37%	86%
Fragmentation - No. of Parcels		
Mean	1.34	1.23
Standard Deviation	1.31	1.40
One parcel	56%	72%
Over one parcel	44%	28%
Type of Irrigation		
Basin	77%	20%
Spray	19%	74%
Both	4%	6%
Availability of Electric Power		
Available	22%	64%
Not Available	78%	36%
No. of Permanent Male Workers		
Mean	2.35	6.19
Standard Deviation	1.93	13.02
2 and over	68%	44%
Over 2	32%	66%
Investment - % of Total Investment		
Homes and Rooms	48%	19%
Irrigation Equipment	13%	31%

Source : LULUJRP data for Western Libya - 1968.

5.1.2 The Chronology of Change

A broad outline of recent agricultural history was given in section 2.2, and in this the major events affecting agriculture in Western Libya were highlighted.

The period of Italian colonisation and development ended in January 1943 in Western Libya when the British Military Administration (B.M.A.) took over government. The British Administration was anxious to maintain agricultural production, and retained the Italian farmers, so that the Italian population was still 40,536 in 1946 in Western Libya according to British estimates.[1]

Investment during this period of British administration was not at pre-1939 levels, however, and agriculture did not develop at the same pace as in the Italian period. Independence in 1951 introduced uncertainty in the Italian community and despite reassurances a number left, so that by 1954 there were 37,655 Italians in Western Libya according to national census figures.

In another aspect independence brought improvements in that there was an increase in the foreign assistance extended to Libya. Table 5.3 shows in some detail the volume and source of foreign assistance for the post-independence years, and until oil revenues became important.

Table 5.3

Libya

Foreign Assistance 1950-1965

£L mn.

	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65
UK & French Grants	1.35	1.46	2.23	1.92	2.91	-	-	-	-	-	-					
L.P.D.S.A.			.44	.72	1.12	1.05	1.02	1.47	.25							
UK Grain Grants			.25	-*	-*											
UN Technical Assistance		-	-	.17	.19	.22	.26	.26	.26	.26	.22	.22	.22	1.85	1.00	.82
US Grants			.64	.50	1.52	6.15	4.62	5.89	5.61	11.20	10.85	6.92	6.86	5.44	2.93	.91
UK Grants						2.79	2.75	3.00	4.63	3.25	3.25	3.25	3.25	3.25	3.25	
TOTAL	1.35	1.46	3.56	3.31	5.75	10.20	8.66	10.63	10.75	14.71	14.32	10.39	10.33	10.54	7.18	1.75

* underestimates '-' no information

Source: Bank of Libya, 'Statistical Supplement', Economic Bulletin Tripoli, July 1967.

This foreign assistance permitted development in a number of sectors, and especially in agriculture, with research and other projects being commissioned. For example the hydrological and land resource studies of Cederstrom[2] and Stewart,[3] and agricultural schemes such as that at Wadi Ki'am.

The early years of independence were years when there was for the first time a surplus of national revenues over national expenditures, as a result of the foreign assistance; indeed it was not until 1966 that oil revenues brought the balance into surplus again. The effect of increased foreign assistance between 1951 and 1955 is shown in Figure 5.4., as is the importance of oil revenues after 1961.

The period 1957 to 1961 was interesting as a time when despite a high level of foreign assistance national revenues at first declined, and then rose more slowly than between 1951 and 1956. It was also the period when oil exploration was getting under way. In 1958 and 1959 national revenues began to rise again, mainly as a result of oil company activity, and partly because of especially high U.S. grants (Table 5.3).

The general impact of these economic changes in the agricultural sector were important. During the British Military Administration and in the early years of independence farming 'was running down,' and many ex-Italian farms were less productive in relation to activity in the 1930s. Traditional farming continued at a mainly subsistence level.

A number of Italian farms were sold at, or soon after, independence, either to Libyan farmers or in some cases to Palestinian entrepreneurs. The latter developed advanced farms, but in general, apart from government sponsored schemes supported by foreign aid, there was little important development in agriculture until after 1961.

Fig. 5.4

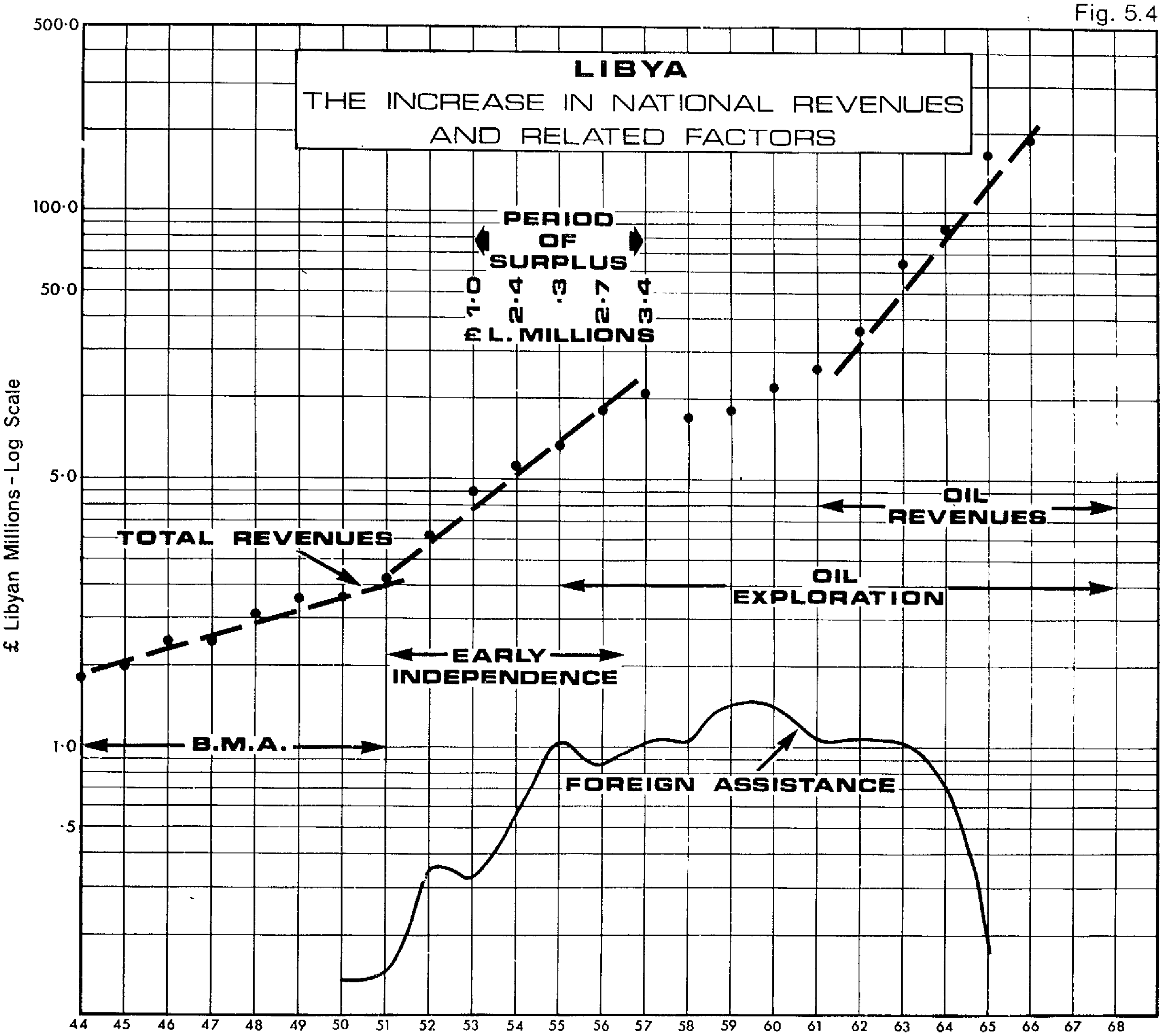

LIBYA
THE INCREASE IN NATIONAL REVENUES AND RELATED FACTORS
500·0
100·0
50·0
5·0
1·0
·5
£ Libyan Millions - Log Scale
PERIOD OF SURPLUS
1·0 2·4 ·3 2·7 3·4
£ L. MILLIONS
TOTAL REVENUES
OIL REVENUES
OIL EXPLORATION
EARLY INDEPENDENCE
B.M.A.
FOREIGN ASSISTANCE
44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68

Table 5.4

Libya

Total Revenues and Expenditures 1944-1967

£L. mn.

	'44/45	'45/46	'46	'47	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65/66	'66/67
Revenue	1.8	2.0	2.5	2.5	3.1	3.5	3.7	4.2	6.2	9.3	11.2	13.3	18.1	20.4	17.0	18.4	22.4	25.7	36.0	63.4	85.8	165.8	187.9
Expenditure	2.0	2.2	2.8	3.9	4.6	4.0	5.5	5.9	6.6	8.2	8.8	13.0	15.4	17.0	20.0	20.6	28.3	34.5	44.4	65.2	100.8	171.8	177.9
Surplus										1.0	2.4	.3	2.7	3.4									10.0
Deficit	.2	.2	.3	1.3	1.5	0.5	1.8	1.7	.4						3.0	2.2	5.9	8.8	8.4	1.8	15.0	6.0	

Source : Bank of Libya, 'Statistical Supplement,' Economic Bulletin, July 1967.

In the early 1960s oil revenues were made available by the government to Libyan farmers for the purchase of land, and very important changes date from this period. It will be the purpose of the next section to identify, and where possible quantify these changes in a number of case study areas, and to show that farm development in the Tripoli triangle was taking place on ex-Italian farms. Considerable intensification was evident and irrigation was being extended to areas which were under dry farming, or were neglected in the early days of independence.

5.1.3 The Areas of Detailed Study (see Figure 5.5)

Two areas of detailed study have been made in order to examine the intensification of farming on ex-Italian farms. The first is an area ten kilometres east of Tripoli, in the mudiriyah of Talbighah and including a small part of the mudiriyah of Jadidah. The area extends 4.0 kilometres east to west and 8.0 kilometres north to south, i.e. 32.0 square kilometres, or 3200 hectares. (See Figure 5.5) This area includes both 'traditional' and 'modern' farms.

The second area is at Suwani bin Yadim, 21 kilometres south of Tripoli. It covers an area of 20 square kilometres (2000 hectares) (See Figure 5.5), and includes 'modern' farms only.

1. Talbighah

The main evidence confirming the intensification of agriculture on ex-Italian farms is in the form of air photographs, taken in April 1953 and in February 1968. The latter were flown especially for this thesis, although some of the material was also included in the Final Report of the Libyan University-London University Joint Research Project. The photographs at the 1:5,000 scale are available in the folder of enlarged photos, Photos 1 and 2.

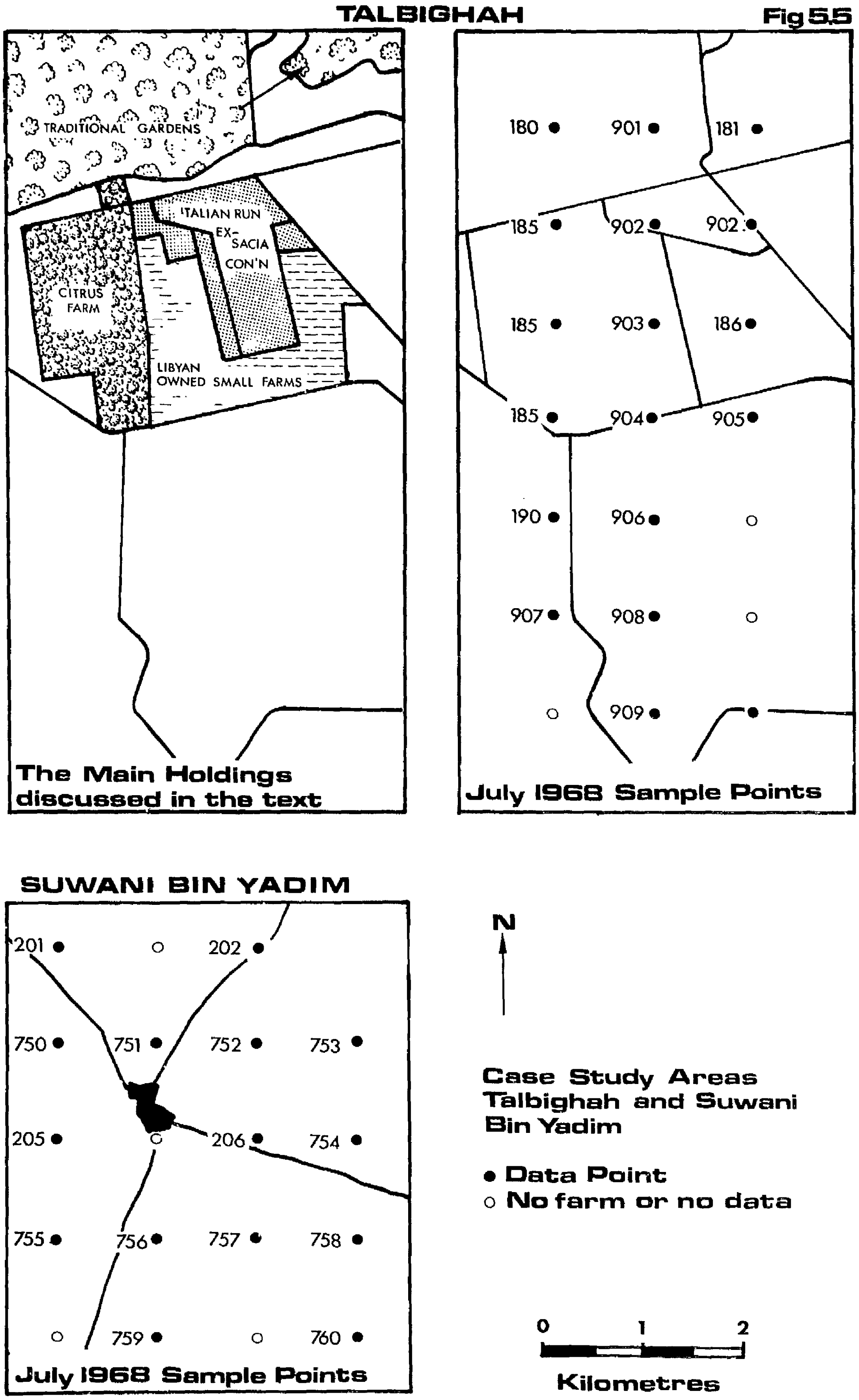

TALBIGHAH
TRADITIONAL GARDENS
ITALIAN RUN EX-SACIA CON'N
CITRUS FARM
LIBYAN OWNED SMALL FARMS
The Main Holdings discussed in the text
180
901
181
185
902
902
185
903
186
185
904
905
190
906
907
908
909
July 1968 Sample Points
SUWANI BIN YADIM
201
202
750
751
752
753
205
206
754
755
756
757
758
759
760
July 1968 Sample Points
N
Case Study Areas Talbighah and Suwani Bin Yadim
● Data Point
○ No farm or no data
0
1
2
Kilometres

Fig 5.5

Approximately 11% of the case study area was traditional irrigated farm-land, located in the north-east of the area. The pattern of settlement and farm layout distinguished this area of traditional farming from the modern agriculture which characterised the majority of the area.

The photograph taken in the spring of 1953 shows very clearly that very little cultivation was in progress at that time. Less than 5% of the Italian farm lying to the south of the main highway which crosses the area (W.SW - E.N.E) in the north was under field crops, and there were less than ten hectares of citrus. Field enquiry revealed that an area of 180 hectares had recently been sold to a Palestinian immigrant and that at the time of photography over half this area was being planted with citrus. Elsewhere, however, the farms laid out in the 1930s by Italian colonists were neglected. Some output would be derived from the olive trees which covered the whole area, especially as labour could be cheaply hired for picking in this early 1950s period. It was this cheap labour which was an important factor taken into account by the citrus farmer when he began to plant in the west of the area of detailed study in 1952/53. The original costing of the enterprise was done on the basis of general labour at £L 0.15 per day.[4] The effects of subsequent rises in labour costs will be examined in section 6.2

The oil revenues which indirectly brought about this rise in wages affected the case study area in a number of other ways. First it altered the pattern of ownership, and secondly it affected the intensity of land and water use.

Citrus Farm - Jadidah

By 1968 the citrus farm had become an extremely efficient unit with an annual output of over 2,300 tons of citrus per year and

150 tons of olives. The former owner indicated that despite the success of the farm, it was the least rewarding of his many businesses in terms of return on capital and he had no plans in 1968 to expand this or his other farms further. Meanwhile he was still finding it necessary to invest on the farm. In 1966 a fruit packing and washing plant of Spanish manufacture was installed at an estimated cost of £L 30,000. Details of investment for the next agricultural year, 1967/68 were as follows:-

Table 5.5

Investment - Citrus Farm - Jadidah
Agricultural Year 1967/68

£L

Item	£L
Shed extension	7000
Electric pump	1500
Tractor	2000
Plough	400
Mats for fruit picking	180
Well construction	2200
Deepening well	300
Well pipes	300
Underground pipes	4000
Sprinkler pipes	500
Pick-up - small truck	2650
Levelling land	1600
Other equipment	4000
Building materials (for perimeter wall)	24000
TOTAL	50630

Source : LULUJRP Investment data 1967/68 for farm no. 185 Gargour et Fils; with additional information collected by the author.

Thus despite his claim that agriculture gave a low return this farmer was investing heavily. In the 1967/68 period investment ran at a rate of over £L 280 per hectare.[5] This was probably an exceptional level resulting from the very high allocation made to the construction of the perimeter wall, built to improve the security of the orchard. However, in the preceding years major items had also been purchased, for example the packing plant.

All the above data were obtained through personal communication with the farmer and his manager, and although no exact information concerning total 'turn-over' was made available it was possible to deduce an approximation from outputs and average market prices. A farm income of between £L 120,000 and £L 130,000 seemed probable for the year 1967/68. In relation to such an income, investment at £L 50,630 was therefore at a very high level.

One other factor was important in 1967/68, the building of the new highway at the northern edge of the farm. Some one or two hectares were sold compulsorily, but more important an unproductive area of the farm was 'quarried' for road building material. It would appear that the owner was returning the profit from this exercise to the farm in the form of the perimeter wall, which had become necessary at the road boundary in any event as the hedge and trees which had previously provided privacy and security were lost through the road widening of 1967/68.

The above analysis of intensification in terms of output, income and investment should be supplemented by some additional information about the farm, to illustrate that this was probably the most intensive agricultural enterprise in Libya, and therefore not representative of the development general on modern farms.

With 150,000 trees, the number of trees per hectare was 830, a very high density not equalled by any other farm of over five hectares in Libya. Hill, describing the farm in 1960,[6] indicated that its development had been similarly progressive during its early years (1952-1959). The farm had been purchased in 1952/53 for £L 8000, and between 1953 and 1959 over £L 120,000 had been invested in its development. Field crops such as potatoes and ground nuts were a feature of the cropping in the 1950s, but it had always been the intention of the farm management to make the farm 'completely citrus as soon as possible.'[7] The owner recalled this period in discussion in 1968, and remarked that it was from his experience at that time that he deduced there to be no point in growing crops in Libya which could be grown more efficiently and more cheaply elsewhere. He was referring specifically to the potato which was very demanding of water and would, he claimed, always be imported more cheaply than the Libya grown product because of the relatively high cost of irrigation water in Libya. Competitors in temperate areas did not experience the soil moisture deficiencies of coastal Libya which necessitated costly supplementary irrigation.

In other respects this farm was special. The records maintained by the manager and his clerical staff were comprehensive and of a very high standard. The existence of such records was symptomatic of the quality of management associated with the farm, both in terms of the handling of investment and the use of equipment, but especially in matters concerned with the recruitment and supervision of permanent and temporary labour. An examination of wages records indicated that some of the labour force (over 10%) had been employed on the farm since the beginning of tree-planting in 1952. Visits to the farm during 1967 and 1968 showed that there existed on the farm a healthy relationship between work-force and management, such as was very unusual in Libya at the time. The motivation of wage labour was proving very difficult to maintain or establish on farms throughout the country, and especially on farms elsewhere in the Talbighah area, where Tunisian farm workers were becoming a common feature. The former Gargour farm had not found it necessary to resort to the employment of foreign labour.

The pattern of activity and management on the former Gargour farm was therefore a phenomenon in agricultural Libya, and its existence contradicted a feeling which was growing in the country that the organisation of a commercial enterprise, agricultural or otherwise, according to the Western capitalistic model and using a locally recruited work-force, was impossible.

In terms of profitability it has been hinted already that returns per hectare were not consistent with the very high level of investment on the former Gargour farm. Investment at over £L 280 per hectare in 1967/68 compared with estimated returns from sales of £L 720 per hectare. It should be remembered, however, that the £L 280 per hectare was partly made possible by the sale of land as well as of sand and gravel in connection with the new road. Regrettably it has not been possible to arrive at a figure of profit per hectare as the other expenses of production could not be determined completely. In the absence of such details the figure of £L 720 per hectare, reflecting the turnover per hectare, will be used as a crude index for the comparison of the former Gargour farm with other farms in the case study areas. It will be shown that estimated returns of £L 200 per hectare were average in the area, and lower returns were common especially on farms which were essentially part-time enterprises.

SACIA* Farm retained under Italian management

The SACIA concession originally comprised over 600 hectares, of which all but 180 hectares had been sold by 1968. Two main periods of sale occurred, the first immediately after independence when areas in the west were sold, including the area sold to Gargour et Fils, and the second after oil, when smaller plots of two to teh hectares were sold to Libyan farmers.

In terms of the intensification of agricultural activity, this remnant of the former SACIA concession provides further confirmation that intensification did take place after oil and prior to 1968. The enlarged air photos 1 and 2 in the folder illustrate the general inactivity on the ex-concession in 1953 (Photo 1). By 1968 (Photo 2) the 180 hectares of the reduced farm were still Italian managed and like other farms in the area had begun to be more intensively cropped with field crops. Over 40% of the farm was being used for growing alfalfa and none of the area so used was being cropped in 1953. The area of the SACIA farm can be seen in the centre of the enlarged photo 2, where it contrasts with the former Gargour farm in the west and the smaller Libyan holdings to the south west, south and east.

The tree crops planted regularly over the whole of the old concession had been the only major contributor to farm income in 1953. This contribution was thought by the farm manager to be similar in terms of tons per hectare of output in 1953 and 1968, but in terms of relative value of production field crops had become much more important by 1968.

The level of investment on the farm in 1967/68 although lower than on the neighbouring Gargour farm, was nevertheless considerable at £L 4910 for the year, or £L 27.3 per hectare.[8]

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* Societa Anonyma Coloniale Impressa Agricola.

It should be noted that the investment was exclusively on equipment or young trees, and this direction of investment indicated a degree of confidence in the agricultural future of the farm. The existing resources of the farm were significant also. Investment was taking place on items such as tractors and irrigation equipment with which the farm appeared to be already reasonably well provided. There were already five tractors on the farm in 1967, that is before the purchase of the new vehicle, and 4600 metres of irrigation pipe before the purchase of 600 metres of new pipe. Clearly the further investment in the tractor was part of a continuing process of replacement or expansion, and the acquisition of spray irrigation equipment, of which there had been relatively little previously was an indication of anticipated expansion in this type of farming.

This second farm, also a relatively large unit, confirms therefore, the proposition that the cultivation of land had become more intensive in the Talbighah/Jadidah case study area since oil, and that in 1967/68 this was a continuing process.

The Libyan owned farms

Changes of ownership have been referred to as one of the ways in which oil revenues had affected the Talbighah/Jadidah area. The second phase of selling associated with the former SACIA concession was the 'post oil revenues period' of the early 1960s. Small plots of between two and ten hectares were sold at £L 200 per hectare[9] from 1963 onwards (compare the 1952 price to Gargour et Fils of £L 163 per hectare). Land prices rose rapidly in the 1960s and by 1968 land was changing hands at four times its 1963 price.[10]

The air photos (photos 1 and 2 in the folder) show how the cropping pattern had changed between 1953 (pre-oil) and 1968. Much more land was irrigated in 1968, with between 20 and 40 per cent of these

Table 5.6

Comparison of Farms in the Talbighah/Jadidah Case Study Area

- excluding traditional farms

July 1968

		Farm 185 Former Gargour Farm	Farm 902 Former Remnant of SACIA Farm	Libyan* Owned Farms
Total area	ha.	180	180	186
Average Farm Size	ha.	180	180	21
" area cultivated	ha.	180	15	17
Labour intensity - full-time men, women & boys per ha.		0.24	0.08	0.25
Total tractors		8	5	5
Tractors per 100 ha.		4.4	2.8	2.7
Irrigation pipes per ha. (underground & spray) metres		72	29	12
Investment per holding		£L 50630	£L 4910	£L 887
Investment per ha.		£L 281	£L 27	£L 43
Estimated sales per ha.		£L 720	£L 150	£L 150

Source : Questionnaire survey conducted by the author in the case study area July 1968, and supplemented by interviews with farmers during the preceding year.

* Libyan owned farms include two on the former SACIA farm (Farms 186 and 903), and seven others located to the south. See Figure 5.5.

new holdings subject to irrigation and intensive methods of cultivation compared with a negligible proportion prior to the change in ownership.

Photogrammetric evidence also gives some notion of the investment which had taken place up to 1968 on these small farms. 95% of the 47 holdings had already completed or had almost completed a permanent dwelling. On the rest farmers were contemplating such an investment. Such dwellings cost between £L 1800 and £L 3000 at the time of the study, and resources for these investments came as they had for the land in the first place, mainly from savings from salaries earned by members of the family, usually in Tripoli.[11]

It was to housing that the first investment resources were allocated. Thereafter wells and irrigation equipment were financed, and young fruit trees planted. Each farm acquired at the time of purchase a number of olive trees planted before 1940 (see photo 1 in the folder), but the new owners realised that their relatively small holdings could only be viable if a more valuable tree crop were raised. Apricots, plums and citrus were planted therefore, and until these trees matured field crops were grown, such as alfalfa and tomatoes. The latter were also thought to be a possible second crop, even after the fruit trees (other than citrus) had matured.

Questionnaire surveys[12] provide further information about the intensification of farming on these Libyan owned farms. Five of the nine farms sampled possessed tractors in July 1968 and most were improving their irrigation equipment. Of the £L 43 per hectare invested in these farms in 1967/68, 20% was on irrigation and related equipment and a further 15% on well digging or well deepening.

From this examination of the various farming enterprises on the ex-colonist farms it has become clear that agricultural activity in such areas was much more vigorous in 1968 than in the years before oil. At this stage no comment will be made concerning the long-term possibility of maintaining agricultural output at the 1968 level nor concerning the continuation of the trend in investment and intensification. Comment will appear in section 6.1 of Chapter 6.

2. Suwani bin Yadim

The Suwani bin Yadim case study is located 21 kilometres south of Tripoli. Its location within the total study area is shown in Fig 2.1.1, and the location of sample points within the case study area are shown in Fig 5.5.* Comparative photographic illustrations appear in Figs 5.7 and 5.8, and these photographs have been enlarged to a scale of 1:5000, and are included in the folder at the end of the thesis (enlarged air photos 3 and 4).

The area was wholly ex-colonist in agricultural terms as revealed by the air photographs which show a regular pattern of farm layout and tree planting. The 1953 photograph reflects the generally 'run-down' character of Libyan agriculture at that time ; a situation to which reference has been made already on page 124 in this chapter. There is little evidence of 'inter-cropping' between the olive and almond trees, whether in the form of rain-fed or irrigated crops, and many plots were apparently completely neglected.

The position was very different in 1968, and the photograph for June of that year shows the considerable extension of irrigated farming. The photograph also shows that by 1968 the area was, as in Talbighah, being farmed in much smaller units, and fieldwork proved that less than

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* It should be noted that the area being discussed in this section has been referred to as 'area of detailed study' in Figs 2.2.1 and 5.5.

10% of the area was under Italian ownership or management. The works of Cederstrom would indicate that a much higher proportion of the case study area was run by Italian farmers in the late 1950s. A figure of 70-80% seems probable* for the extent of Italian ownership.

The departure of the Italian farmers coincided with the improvement in the economic situation in Libya in the early 1960s (Fig 5.4). The allocation of family income for investment was following a similar pattern in this case study area as in Talbighah. Housing was taking a larger part of such investment, even in 1968, but investment in irrigation and other mechanical equipment also figures prominently on the farms of the Suwani bin Yadim area according to the questionnaire data collected for the 1967/68 agricultural year. Data for the sample farms shows the following pattern of investment for 1967/68.

	%
Real property and construction	22.6
Irrigation equipment	60.2
Machinery	2.8
Transport	10.8
Land Reclamation	3.7
Total Investment	100.1**

** rounding error

The data also showed the investment per farm to be at the rate of £ Libyan 1772, and per hectare £ Libyan 65.0.

The very heavy investment in irrigation equipment and associated well drilling or deepening confirms the statement that irrigated farming was being intensified on ex-colonist farms. This, together with the results of earlier investment (i.e. in the period 1963-67) in the form of irrigated crops which appear in the air photos adds further evidence to confirm the proposition that irrigated farming was being intensified on ex-colonist farms. The implication of such development of underground water resources will be examined in section 6.1.4 of Chapter 6.

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* Cederstrom, D. J. and Bertaiola, M., Ground Water in the Tripoli Area - Tables of Well Records, USOM, Tripoli, 1960. p.132-136.

5.2. The Extension of Irrigated Agriculture

It has been shown in the preceding section, section 5.1., that farming, especially irrigated farming, became more intensive after 1961 in the Tripoli triangle. It is intended next to show that new areas were also taken over for irrigated agriculture, and that irrigated methods have been applied in areas which were previously dry farms.

5.2.1 The Areas Available for Extension

It has already been indicated that the study area was not a homogeneous productive farming region in 1968. Many areas were dune covered and of no agricultural importance within the area defined as the Tripoli triangle, and the margins of the area were everywhere arid and impossible for other than shifting or irrigated agriculture.

There were many areas available for the extension of irrigated agriculture after 1961 when the financing of such development on a public and private basis became possible through the discovery of oil, both within the total study area and at its margins.

Useful data on the position in 1953 have been deduced from air photographs of the Gefar Plain. An examination of 1:24,000 air photographs and mosaics of the study area have permitted an estimate of the area used for grazing, shifting agriculture and of land not used for any agricultural activity. Of the 1402 square kilometres of the total study area approximately 65% could be classified as outside the scope of regular cultivation. Within the area, therefore, there was considerable scope for extension of irrigation especially in such a moisture deficient area.

5.2.2 Case Studies Illustrating the Extension of Irrigated Agriculture 1961-1968.

A comparison of air photographs taken before and after oil (1953[13] and 1966[14] or 1968[15.16]) has been made, with a view to quantifying the areas which had previously been of no agricultural importance, and which by 1966 or 1968 had become productive. Unfortunately the photo cover for 1966 and 1968 is not as complete as that for 1953, and the gaps in the cover are important with respect to the marginal areas in the east and in the extreme west. However, on the basis of the area covered for both the early and later periods, about 80% of the whole 1402 square kilometres, there is evidence that there was a significant shift towards irrigated farming. In the area of comparative photo cover between thirty and fifty square kilometres* of former dunes had begun to be farmed by 1966.

This general review of the area also revealed new irrigated agriculture within the study area, and not necessarily at its margins. However, as it has not been possible to examine the whole study area in sufficient detail, even using air photographs, a number of case studies have been made in areas where it was known that irrigated agriculture was being pursued, both in those areas close to, or between, existing farm enterprises, and also in marginal areas. The locations of the case studies are shown on Figure 5.6

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* The large range 30-50 square kilometres is a realistic figure in view of the photogrammetric methods used, and the scale of the 1966 photography (1:65000).

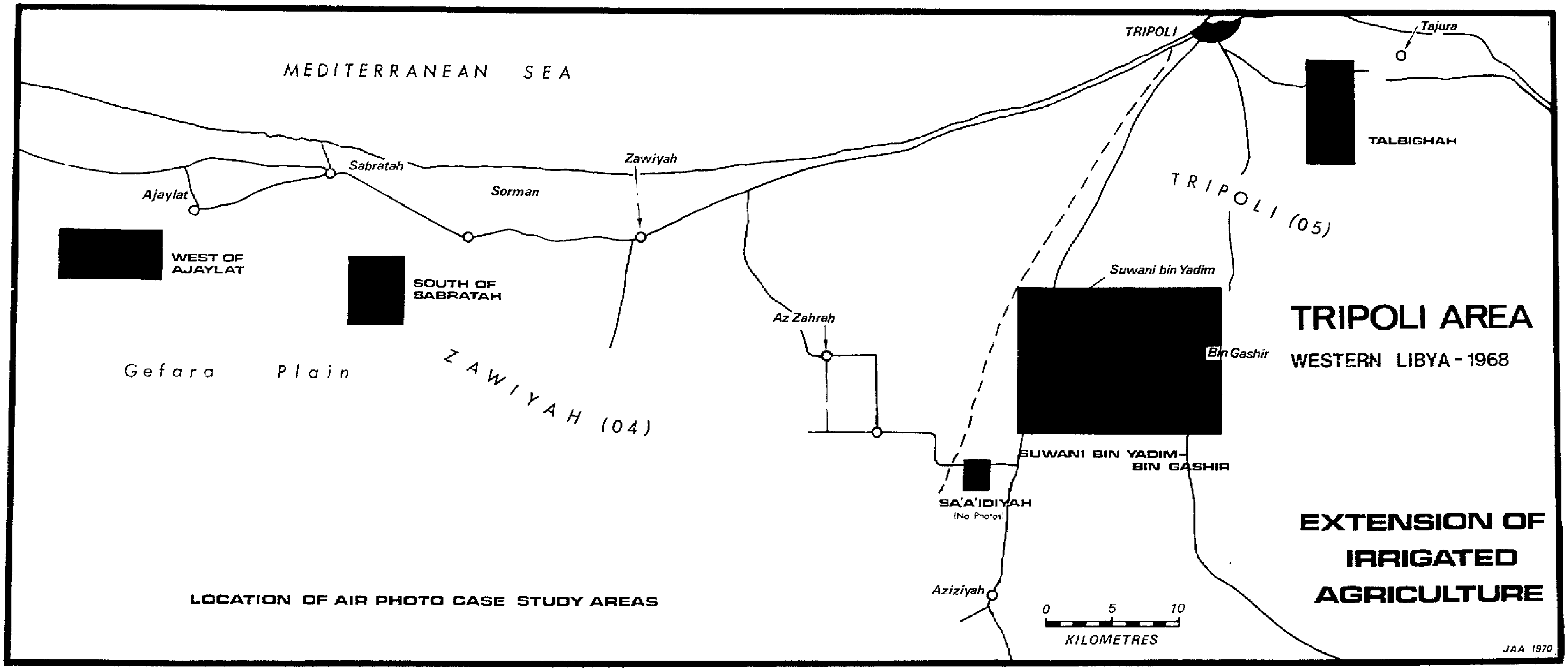
MEDITERRANEAN SEA
TRIPOLI
Tajura
TALBIGHAH
TRIPOLI (05)
Suwani bin Yadim
Bin Gashir
TRIPOLI AREA
WESTERN LIBYA - 1968
SUWANI BIN YADIM-BIN GASHIR
SA'A'IDIYAH
(No Photos)
Aziziyah
0 5 10
KILOMETRES
EXTENSION OF IRRIGATED AGRICULTURE
JAA 1970
Az Zahrah
Zawiyah
Sorman
Sabratah
Ajaylat
WEST OF AJAYLAT
SOUTH OF SABRATAH
Gefara Plain
ZAWIYAH (04)
LOCATION OF AIR PHOTO CASE STUDY AREAS

FIG 5.6

(1.) Areas of Irrigated Farming at the Margins of the Study Area

Two areas in the west of the Tripoli triangle have been examined as examples of completely new enterprises, initiated by coastal farmers with no formal government support. These areas are located to the south of Sabratah and west of Ajaylat respectively.

One further area has been selected in the south of the study area to illustrate the developments sponsored by the settlement authority of the Ministry of Agriculture, at Sa'a'idiyah.

South of Sabratah

Photographs taken in 1953[17] of an area of 22 square kilometres in extent, shows only 1.2 square kilometres to have been used in the recent past for raising crops and these had almost certainly been irrigated. Approximately 70% of the case study area was apparently unusable dunes, while in the south a further 24% of the total area had been used, (although not apparently recently), for shifting or some other temporary form of agriculture.

The position had changed dramatically by 1966,[18] at least when viewed from the air. The same 1.2% was being farmed, but in addition some six square kilometres were under irrigated crops, and one square kilometre had been planted with trees. A further two square kilometres showed signs of having been used recently for field crops. Table 5.7 shows the percentage changes in land use between the mid 1950s and 1966, or 1968, for Sabratah and the other case study areas.

This development in Sabratah was the work of individuals from the coastal settlements and farms near Sabratah and Zawiyah. Such coastal farmers have by tradition the right to plant crops on the Gefara Plain, and these rights of the tribe or the individual were strictly defined. The evidence of previous cultivation shown on the photographs taken in 1953 reflects such activity and its generally transitory nature.

Table 5.7

The Extension of Irrigated Farming - Case Study Areas

All figures are percentages

	South of Sabratah		West of Ajaylat		Sa'a'idiyah	
	May-Jan 1953	May 1966	May-Jan 1953	May 1966	June 1953	July 1967
Irrigated Farms, Under Crops	5.4	27.3	5.0	28.5	-	31.0
Recently cultivated areas*	0.4	12.3	0.6	3.5	-	30.0
Temporary agriculture from previous years**	23.8	-	21.0	-	15.3	-
Dunes/grazing	70.4	55.9	73.4	68.0	84.7	37.0
Woodland	-	4.5	-	-	-	2.0
	100.0	100.0	100.0	100.0	100.0	100.0

Source: 1. Air photographs Fairey Surveys Ltd May-July 1953
Aero Exploration May 1966
2. Fieldwork, LULUJRP July 1967

* Fields within the area of 'Irrigated Farms,' but without crops at the time of the photography

** Areas used by coastal farmers irregularly.

After oil it became possible for these same farms to invest in the sinking of wells and the purchase of modern irrigation equipment. As a result, areas previously used only for catch crops when rainfall permitted became irrigated plots, from which crops were raised throughout the year. In addition dune areas used only for grazing until 1962/63 were taken over and irrigated using the versatile spray method* of irrigation. Table 5.7 shows that all the area classified as 'temporary agriculture' had been taken over for irrigated farming, with tree crops on some plots. The area of dunes, usable only for very poor grazing, had at the same time been reduced overall from 70% to 56%. Within this case study area there had been, therefore, over a fourfold increase in the area affected by irrigation. In terms of production only very imprecise estimates are possible, but in the light of the ephemeral character of most of the farming in 1953 and the higher yields associated with irrigated methods, it seems possible that there was a hundredfold increase in the value of output at constant prices. This increase reflects also the higher value of the irrigated vegetables being grown in 1966 compared with that of dry land grain, the main crop in 1953.

It should also be noted that over a square kilometre of coniferous woodland had been planted in the north of the case study area and there was evidence further south that dune fixing had been attempted with the planting of shrubs. Such activity was confirmed by field visits.

West of Ajaylat

This second case study confirms the extension of irrigation as outlined in the preceding discussion of the area south of Sabratah.

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* Versatile in that changes of slope and elevation do not hinder the extension of the irrigation pipes.

An area west of Ajaylat (see Table 5.7), 40 square kilometres in extent, has been examined and shows that there was a significant shift to irrigated methods after oil. Traditional irrigated farms comprised 5% of the case study area in 1953 ; by 1966 these together with areas developed after 1961 covered 28% of the study area. In addition a further 3% of the area had been used in the recent past for some form of cultivation, and the dune area had been reduced from 73% to 68%. Productivity had advanced in line with that of previous case study area.

An interesting feature of both the area west of Ajaylat and that south of Sabratah was the presence of a number of farmers of Tunisian origin.* Research was not sufficiently extensive to confirm the numbers in each of these areas, nor were questionnaire surveys conducted, but discussion with farmers in the area did reveal the importance of these arrivals from Tunisia with respect to labour supply. Without them the new enterprises could not be maintained, especially as a number of the families from Tunisia had agricultural skills with a direct relevance to modern methods of irrigation as well as the cultivation of the varieties of crops grown under such conditions.

It was not possible to discover whether the Tunisians owned any land themselves, but there was some evidence that they were working land on their own behalf. A general sense of insecurity attended all their activities, both in terms of their general acceptance of the local population, and also in their legal position in Libya.

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* The return of individuals born in Libya who had subsequently moved to other countries in the Middle East and North Africa (especially Egypt and Tunisia), was a feature of the periods of oil exploration and discovery. Such people returning from Tunisia were, however, regarded as 'Tunisians' by the local population.

Although most were legal entrants to the country,* some had entered Libya without the necessary papers. These were at the same time, however, encouraged to stay by the local farmers who were dependent upon their assistance on their farms.

It is perhaps significant that these new areas of irrigation were at the extreme west of the Tripoli triangle and closest to Tunisia. They are the most accessible areas for immigrants, legal and illegal, coming from Tunisia, yet they were at the same time relatively remote from the main centres of population, Sabratah, Zawiyah and Tripoli, and were therefore less closely supervised by immigration officials. These factors together with the disincentives to local farmers to reveal the presence of illegal residents have led to a concentration of former Tunisians in these western areas.

Finally the absence of Italian activity in such areas in the colonial period should be mentioned. That the area was not developed by them has contributed to the remoteness mentioned in the previous paragraph. It also reflects the unease of the Italian authorities with respect to investment in an area where underground water resources were uncertain. Farmers indicated in 1968 that water levels were falling from year to year but unfortunately it was not possible to quantify this decline in either of the case study areas. Also ground water problems at coastal Sabratah to the north confirm a disposition of ground water resources inimical to the long-term development of irrigated agriculture in the western part of the Tripoli triangle. Such matters will be treated in more detail in section 6.1.

* Ess. Fekini, prime minister of Libya in the 1963 period, and himself having spent a period of residence in Tunisia, did encourage the return of former Libyans from Tunisia during his time as premier. He saw that the services of such families could be useful to Libya, and he was instrumental in making tenancies available to them on the new government farms at Sa'a'idiyah (See next case study).

Sa'a'idiyah

The Sa'a'idiyah area was also developed after oil, but unlike the Sabratah and Ajaylat extensions of irrigation, it was the result of government planning and investment.

It will be demonstrated elsewhere (Section 6.1) that groundwater resources, upon which such development depends, have been proven inadequate, so that the progressive expansion of the estate was discontinued.

Before oil the Sa'a'idiyah area was used for grazing and occasionally for dry cereal crops depending on the season's rainfall.[19] By 1964 the northern part of the estate had been laid out and during the following two years farmers took over the holdings. It has been observed already that many of these families had returned to Libya from Tunisia, and were judged by the government of the time to be suitable tenants, and in due course, owners of these new four hectare plots.

Like other government farms in Western Libya the area covered by crops in both summer and winter was high compared with private farms.[20] Only 37% of the case study area was classified as fallow following fieldwork in the winter of 1967. This compares with 52% and 53% for equivalent private farms in the more favoured north of the Tripoli triangle at Talbighah/Jadidah and Suwani bin Yadim respectively.[21]

The Sa'a'idiyah area further confirms the extension of irrigated agriculture in the Tripoli triangle. Productivity in relation to previous output for the area increased remarkably, especially as the crops raised in summer were the valuable cash crops of tomatoes, ground nuts and melon[22] (7%, 19% and 16% respectively by area).

(2) Areas of New Irrigated Farming on or between Existing Farms, or on Previously Unirrigated Farms

Studies have been made of areas recognisable in the 1950s as farmland, although the extent of utilisation was by no means complete, and much of the land was used for winter rain-fed crops only, with little irrigated summer activity.

In the next two studies, of Talbighah/Jadidah and the Bin Gashir/Suwani bin Yadim areas (See Figs 5.6 and 5.7), an attempt will be made to establish the extent to which previously unused or neglected areas have been developed for agriculture or woodland, as well as the extent to which areas used previously for rain-fed agriculture have been converted to irrigated farming.

Again air photos have proved a very valuable source of data.

Talbighah/Jadidah

In the discussion of these 40 square kilometres in section 5.1, the area was shown to be one of intensifying agriculture in 1968.

A close examination of photographs for 1953[23] and 1968[24] shows important changes with respect to previously unused areas. Table 5.8 summarises the changes, indicating that the area used for grazing (dunes/grazing on Table 5.8) had been reduced from 24.0% to 12.6%. Part of this reduction must be attributed to the increase of woodland from 2.0% to 5.6%, and part to the use of some of the dune area (4.3%) by recent settlers.* In brief therefore there has been some extension of irrigated farming into areas unused before oil, estimated to be 6% or more (i.e. including the 4.3% of recent settlement).

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* These 'settlers' were mainly from Tunisia and living in temporary dwellings. There were, however, a number of permanent dwellings being erected in 1968.

Table 5.8

The Extension of Irrigated Farming - Case Study Areas

All figures are percentages

	Talbighah/ Jadidah		Bin Gashir/ Suwani bin Yadim	
	April[1] 1953	Feb.[2] 1968	June[1] 1953	June[3] 1968
Farms Under Crops - Irrigated	25.0	54.7	18.7	26.6
- Unirrigated	47.1	20.8	39.7	33.1
Recently cultivated areas*	-	4.3	-	-
Temporary agriculture from previous years	-	-	-	-
Dunes/grazing	23.9	12.6	27.0	20.4
Woodland	2.0	5.6	11.3	16.4
Waste and Built-up	2.0	2.0	3.3	3.4
	100.0	100.0	100.0	99.9
	(40 sq.km.)		(140 sq.km.)	

Source: Air photographs (1) Fairey Surveys Ltd April/June 1953
(2) Aero Exploration Feb 1968
(3) Aero Exploration May 1966

* Fields within the area of 'Irrigated Farms', but without crops at the time of the photography.

Note on area measurements. Photographs were sampled by grid sampling, the grid was placed over the study areas a number of times at random angles, with random origins. The above figures are estimated to be accurate to within 1% with a 95% confidence (sample size 1000).

The most important extension of irrigated farming in Talbighah/Jadidah came, however, at the expense of dry farming. 47.1% of the study area was recorded as unirrigated farmland in 1953. This amount had been reduced to 20.8% by 1968. Meanwhile the area of irrigated farming had increased from 25.0% to 54.7%, and mainly at the expense of the unirrigated farmland.

Bin Gashir and Suwani bin Yadim

Similar trends were revealed in an area 20 kilometres to the south at Bin Gashir and Suwani bin Yadim. The case study area comprises 140 square kilometres and its location is indicated on Figure 5.6; it was covered by photography in 1953[25] and 1968,[26] illustrated in Figures 5.7. & 5.8.

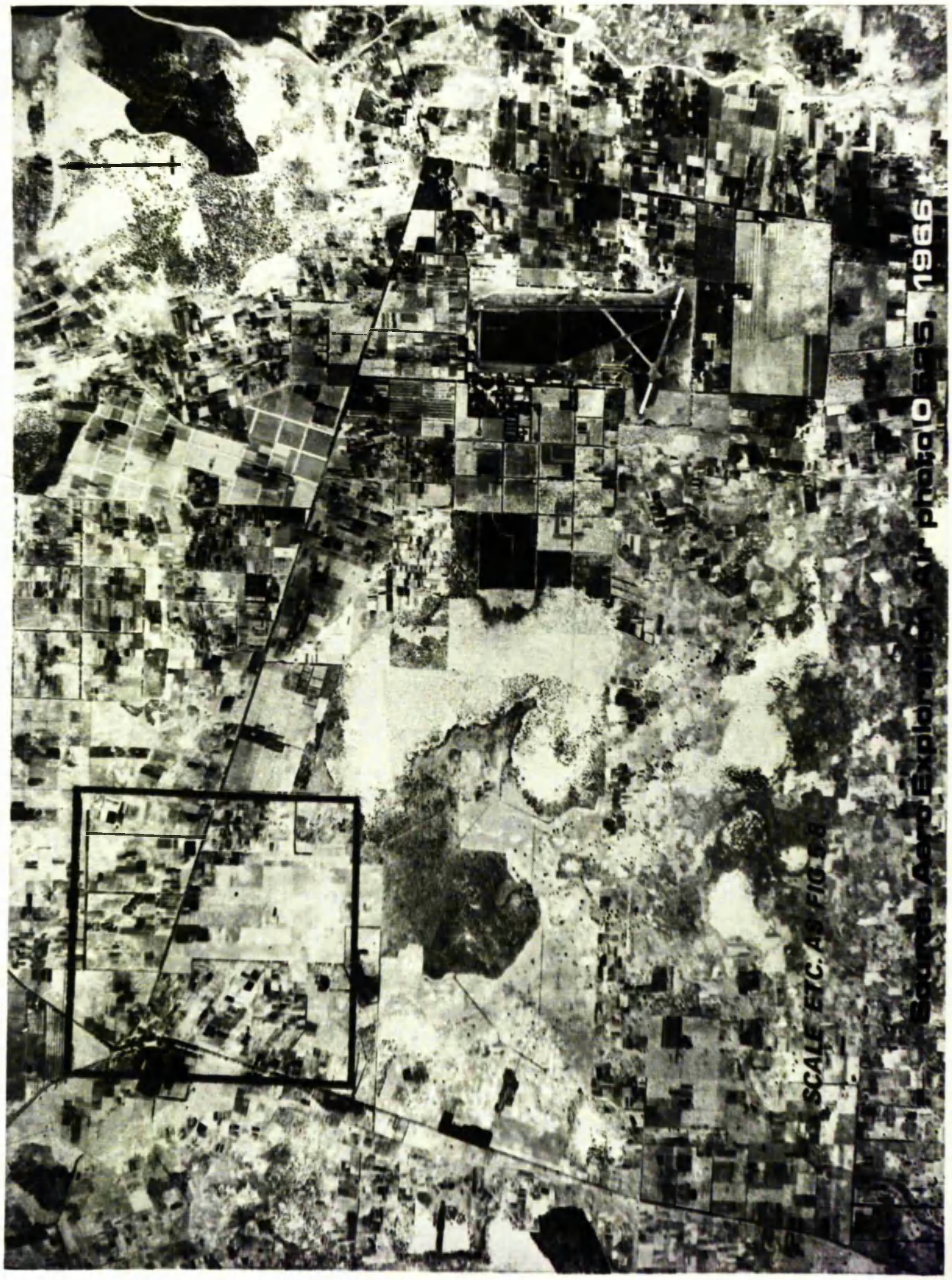
Land which in the earlier period was used only for grazing had been taken over for irrigated farming. Half of one per cent of the area or 70 hectares had been improved in this way.

Further, a much larger area, 7.4% of the total case study area, or more than 1000 hectares, which in 1953 was being farmed by dry farming methods or raising tree crops (olives and almonds) only, was by 1966 being irrigated. Thus in all the total area irrigated increased from 18.7% to 26.6% at the expense of previously unirrigated or grazed land.

Field work showed that the use of irrigation water had increased sharply with respect to summer crops such as tomatoes and ground-nuts. The impact of the increased water use is discussed in detail in section 6.1.

The evidence for the extension of irrigated agriculture is therefore conclusive for the case study areas, both in those which were marginal in character such as Sabratah, Ajaylat or Sa'a'idiyah, or in areas previously developed where attempts had been made since

BIN GASHIR – SUWANI BIN YADIM JUNE 1953 FIG 5.7



BIN GASHIR - SUWANI BIN YADIM JUNE 1966 FIG 5.8

1961 to take over neglected farms and dune areas, for example Talbighah/Jadidah and Bin Gashir/Suwani bin Yadim.

5.3 The Reduction in the Distinctiveness of the Farm Types

European colonisation has left its mark on all North African countries. Farms set up by colonial administrations both by private and government enterprise in Libya since the beginning of the century contrast strongly with the traditional coastal gardens of Libyan farmers. This is well illustrated in the enlarged air photo 1. (in separate folder).

Italian run farms were generally larger than Libyan owned holdings, the shape of the farms were regular, and the degree of mechanisation greater, especially with respect to irrigation. The electric and diesel pump together with the spray method of irrigation were the rule on colonist farms but were almost unknown on traditional holdings until after oil. The colonists' farms were also distinct in that they were located further from the coast than the traditional irrigated gardens, as the latter had already taken advantage of the most accessible aquifers.

In this study, however, we are interested in the situation in the years immediately before oil and the changes consequent upon its discovery. That there was in 1968 a distinctiveness between traditional and ex-colonist will first be established (Section 5.3.1), and then it will be shown that developments since oil have led to a reduction in the distinctiveness of the two farming styles.

Before oil the characters of the two types of farm were quite separate, and even by 1968 the separateness was clearly identifiable. There were sharp breaks in the frequency distributions of major distinguishing variables marking this separateness, in for example, farm size. Table 5.9 shows that the mean farm sizes of the two types of farm were very different, at 4.0 hectares and 31.3 hectares for 'traditional' and 'modern' farms respectively. The discontinuity in the distribution is confirmed by the standard deviation figures of 2.8 and 4.8 respectively, indicating a relatively small range in farm size in these two types.

5.3.1 Evidence of Distinctiveness

Two methods have been used to present evidence to distinguish the main qualities of the traditional and modern farms, and to highlight their distinctiveness. Both are basically subjective in that a number of variables have been selected as indicators. This selection has, however, been made on the basis of a very thorough knowledge of the study area and of Western Libya generally, partly derived from the close supervision of the Joint Project (LULUJRP) questionnaire survey of 1968. The selection is nevertheless subjective and this should be remembered when the multivariate and other techniques are used in an attempt to derive more 'scientifically' additional indicators. Within these very commonly encountered limitations, however, it is felt that the distinctiveness of the traditional and modern sectors have been satisfactorily quantified in this section.

(1.) Selected data from the farm survey of 1968

Scale and intensity of farming (Table 5.9)

Information concerning the size of holding and the proportion of the farm cultivated and under various crops is summarised in Table 5.9. Farm size has been established already as a useful indicator of farm type. Table 5.9 also shows that a much higher proportion of the traditional holdings was under crops in the 1968 agricultural year than was the case on the generally much larger ex-colonist farms. Likewise

Table 5.9

<u>Variables which Distinguish Traditional and Ex-colonist Farms</u>

<u>Scale and Intensity of Farming</u>

		Type 1 Traditional Libyan Holdings (95 holdings)			Type 2 Ex-colonist Holdings (181 holdings)		
	Units		Std. Dev.	%		Std. Dev.	%
Mean Farm Size	ha.	4.0	2.8		31.3	4.8	
With One Parcel	%			56%			72%
" Two or More Parcels	%			44%			28%
Mean Area Cultivated	ha.	2.4*	2.7		10.6	6.5	
% cultivated	%			60%			34%
Mean Area under Cereals	ha.	1.5*	1.9		2.9	3.6	
% under Cereals	%			37%			9%
Mean Area under Vegetables	ha.	1.4*	2.0		2.0	2.2	
% under Vegetables	%			35%			6%

* Crop areas total more than cultivated areas because of double cropping.

Source: Data from the survey of 276 irrigated and semi-irrigated farms in Western Libya, LULUJRP 1968.

cereals and vegetables figures as much larger proportions on the traditional farms than on ex-colonist holdings. It should be noted that our definition of intensity is purely with respect to the area covered by crops and in no way reflects intensity in terms of yield per hectare or according to levels of inputs and outputs per unit of area. Since, however, the traditional farms also had a relatively larger proportion irrigated than did the ex-colonist modern farms (Table 5.10), (45% compared with 20% of the total farm, and 75% compared with 60% with respect to the cultivated area), then yields per hectare were likely to be comparable if not higher on such farms identified as traditional in farming methods.

Farming methods - labour and mechanisation (Table 5.10)

The manning of farms can be seen to have been different in the two types of farm in 1968 (Table 5.10). The average number of male workers was 2.4 on traditional holdings compared with 6.2 on ex-colonist farms. The standard deviation of 13.0 for ex-colonist holdings indicates a considerable range in the labour requirements of the 'type 2' farms, reflecting the considerable variation in size, with farms up to 3000 hectares in size in the sample, as well as variations in the efficiency of these ex-colonist farms and in their manning policies.

The traditional farms are shown to have been worked by a higher number of men per hectare. In terms of the total farm there were 1.9 total workers per hectare on traditional farms compared with 0.4 on ex-colonist holdings, that is higher by a factor of five times in favour of the traditional farms. The relative position of the two moves slightly in favour of the ex-colonist holdings when the cultivated area of the farm is considered, but even so the traditional

Table 5.10.

Variables which Distinguish Traditional and Ex-colonist Farms

Farming Methods - Labour and Mechanisation

All mean figures are per farm or per hectare as indicated

		Type 1 Traditional Libyan Holdings (95 holdings)			Type 2 Ex-colonist Holdings (181 holdings)		
	Units		Std. Dev.	%		Std. Dev.	%
Labour							
Permanent Workers - Men	per farm	2.4	1.9		6.2	13.0	
" " - Women	"						
" " - Boys	"	2.8	1.9		2.8	1.7	
% of farms with 4 or more male workers of	all farms			14%			39%
Total labour - total farm	per ha.	1.9	-		0.4	-	
Total labour - cultivated area	"	3.1	-		1.1	-	
Mechanisation Including Irrigation Equipment							
Availability of Electricity on	all farms			22%			64%
% irrig'd of - total farm	%			45%			20%
" " " - cultivated area	%			75%			60%
% using spray irrigation of	all farms			21%			80%
Tractors (mean) per 100	cult ha.	2.1			1.8		
Tractors	per farm	.08			.56		

'-' - not available

Source: Data from the survey of 276 irrigated and semi-irrigated farms in Western Libya, LULUJRP 1968.

farms were three times more intensively manned as ex-colonist holdings, with 3.1 workers per hectare on 'type 1' holdings and 1.1 workers per hectare on type 2 farms.

Table 5.10 indicates at the same time that the ex-colonist farms were much more highly mechanised. The availability of electricity, the area irrigated, the method of irrigation and the number of tractors per farm and per cultivated hectare have been taken as indicators. 64% of 'type 2' farms were electrified as compared to only 22% of 'type 1' farms. Also 80% of the ex-colonist farms were using the spray method of irrigation compared with only 21% of traditional holdings. This method of distributing irrigation water requires less labour than the traditional 'basin' method of irrigation; it is also more flexible and in most aspects, other than loss of water through evaporation, it is more efficient. That such methods were more generally available on modern farms should be taken into account when considering the areas cultivated on the two types of farms. 'Type 1' farms it is true had a higher proportion irrigated than did 'type 2' holdings, 75% compared with 60%, but the more effective use of water on the latter would do much to redress the balance in terms of overall yield per cultivated hectare on the two types of farm.

'Type 2' farms were also much more likely to possess a tractor than 'type 1' holdings. About half the former had tractors while only one in ten of traditional holdings had a tractor. It is normal to relate the number of tractors to the number of cultivated hectares and in this measure the 'type 1' farms show up more favourably with 2.1 tractors per 100 hectares compared with 1.8 per 100 hectares on ex-colonist farms. It should be remembered, however, that such averages are misleading in that the 'type 1' holdings were small (average size 4.0 hectares) and so the utilisation of such machinery as tractors was likely to be much less effectively organised on such small units than on the very much larger 'type 2' farms. There was little evidence of the sharing of such machinery on the traditional farms, and so the relatively high average figure of 2.1 tractors per 100 hectares does not properly reflect the very discontinuous availability of tractors on traditional farms.

These variables relating to farming methods probably provide the most important evidence of the difference between 'type 1' and 'type 2' farms.

Land tenure (Table 5.11)

Owner occupation was the most general form of land holding for both types of farm. There was, however, a significantly higher ~~number~~ of tenant farmers on the type 2 farms, with 20% of holdings being such, as compared with only 4% on traditional holdings. Clearly the coastal gardens were part of a long standing system of inherited land holdings, and because of the subdivision of plots on the death of the owner according to the Islamic practice, the holdings have become progressively smaller. So small in fact that there was no possibility of all or part of such plots being leased to others as the output/income from the whole farm was required by the owner, and his family.

This same pressure was not the case on the larger ex-colonist farms. Rather as we have seen in the preceding sections there is evidence of underutilisation of these holdings. Owners of such farms felt able to let part of the area which would otherwise be unused to tenant farmers. The exact average size of such tenant farms has not been computed, but fieldwork indicated that they were relatively small and rarely more than 10 hectares in area.

Table 5.11

Variables which Distinguish Traditional and Ex-colonist Farms

Land Tenure

	Units	Type 1 Traditional Libyan Holdings (95 holdings)			Type 2 Ex-colonist Holdings (181 holdings)		
			Std. Dev.	%		Std. Dev.	%
% of farms held as tenancies	%		-	4%		-	20%
% inside tribal area	%		-	82%		-	57%

'-' not available

Source: Data from the survey of 276 irrigated and semi-irrigated farms in Western Libya, LULUJRP 1968.

Living standard, remoteness and transportation

Criteria concerning the living standards and access to motor transport are also revealing of the distinctiveness of the two types of farm. Although the mean number of rooms per dwelling was not remarkably different at 4 and 5.7 respectively for 'type 1' and 'type 2' farms, it is clear that the ex-colonist farms did have many dwellings with a larger number of rooms as indicated by the standard deviation of 6.9 (cf. 2.6 for the traditional holdings). 37% of dwellings had six or more rooms on ex-colonist farms compared with only 17% on traditional holdings. By 1968 this feature of distinctiveness was becoming less marked. Many uncharacteristically large dwellings had been erected during the preceding three or four years on the 'type 1' farms as a result of the availability of income from 'off-farm' employment. Conversely the position on the ex-colonist holdings had been made less distinct through the erection of many houses of similar proportions to those being built on the traditional holdings during this same post-oil phase.

An indication of the standard of amenities available on the two types of farm is illustrated by the presence or not of electricity. The 'type 2' farms are certainly confirmed as more 'modern' in that 64% had electricity compared with only 22% of traditional holdings.

Although it is to be expected that the ex-colonist holdings show as being more remote than the traditional farms in terms of distance from a village, the difference is not great being of the order of 3.4 kilometres for 'type 1' holdings and 4.9 kilometres for 'type 2' farms on average.

With respect to the method of covering this distance, however, there were significant differences. 44% of traditional

Table 5.12

Variables which Distinguish Traditional and Ex-colonist Farms

Living standard, remoteness and transportation

	Units	Type 1 Traditional Libyan Holdings (95 holdings)			Type 2 Ex-colonist Holdings (181 holdings)		
			Std. Dev.	%		Std. Dev.	%
Living Standards							
% of dwellings with rooms 6 or more rooms	per farm		-	17%		-	37%
Mean rooms	per dwelling	4	2.6		5.7	6.9	
% of farms with electricity			-	22%		-	64%
Remoteness and Transportation							
Distance to nearest main village	km.	3.4	3.3		4.9	4.0	
Method of travel to village - % on foot			-	44%		-	18%
- % by car			-	35%		-	61%

'-' not available

Source: Data from the survey of 276 irrigated and semi-irrigated farms in Western Libya, LULUJRP 1968.

farmers claimed to travel to the village on foot while only 18% walked to the village from 'type 2' holdings. The latter were much more likely to go to the village by car or similar vehicle with 61% indicating this mode of transport, contrasting with a figure of only 35% for traditional farmers. In both cases approximately 20% indicated the use of other means of travel, for example animal transport and public transport.

Investment and loans

In the use of investment resources and in the size of loans obtained in the 1967/68 agricultural year, the two types of farm contrasted strongly. The 1967/68 investment year was relatively soon after the benefits of oil revenues had become generally available, and investment in all agricultural areas was relatively strongly orientated towards house improvement and replacement. Farm 'types 1 and 2' allocated £L 368 and £L 474 respectively to the building of homes or extensions to dwellings. These amounts were not significantly different in size, but in the proportion of total resources allocated to these purposes, however, there was a sharp distinction. 49% of investment on traditional farms went on housing and related building, while it accounted for only 18% of such investment on ex-colonist farms. On the other hand other forms of construction were equally significant on 'type 2' farms, amounting to 19% of the total, while on traditional holdings only 8% of investment went on building other than dwellings.

The 'type 2' farms were also characterised by investment on equipment and machinery. 32% of total investment on such holdings went on irrigation equipment, and 20% on machinery. Figures for 'type 1' farms for these items were only 16% and 8% respectively. Land

Table 5.13'

Variables which Distinguish Traditional and Ex-colonist Farms

Investment and Loans

Figures are in £L per farm and per cultivated hectare

		Type 1 Traditional Libyan Holdings (95 Holdings)			Type 2 Ex-colonist Holdings (181 Holdings)		
Investment	Units	£L per farm	£L per ha.	%	£L per farm	£L per ha.	%
Homes and rooms	£L	368	92	49%	474	15	18%
Other construction	"	61	15	8%	500	16	19%
Irrigation equipment	"	121	30	16%	842	27	32%
Machinery	"	61	15	8%	526	17	20%
Transport	"	128	32	17%	210	7	8%
Land reclamation	"	8	2	1%	79	2	3%
Total investment	"	747	186	100%	2631	84	100%
Other expenditure	"	67	17	9%	132	4	5%
Total expenditure	£L	814	203		2763	88	
Loans	Units		Std. Dev.	%		Std. Dev.	%
% farms with loans over £400	%			0%			27%
Mean size of loan	£L	116	65		1618	2581	
Mean repayment period	years	3.2	3.9		5.9	5.8	
Other sources of loan than Agricultural Bank	%			20%			0%

Source: Data from the survey of 276 irrigated and semi-irrigated farms in Western Libya, LULUJRP 1968.

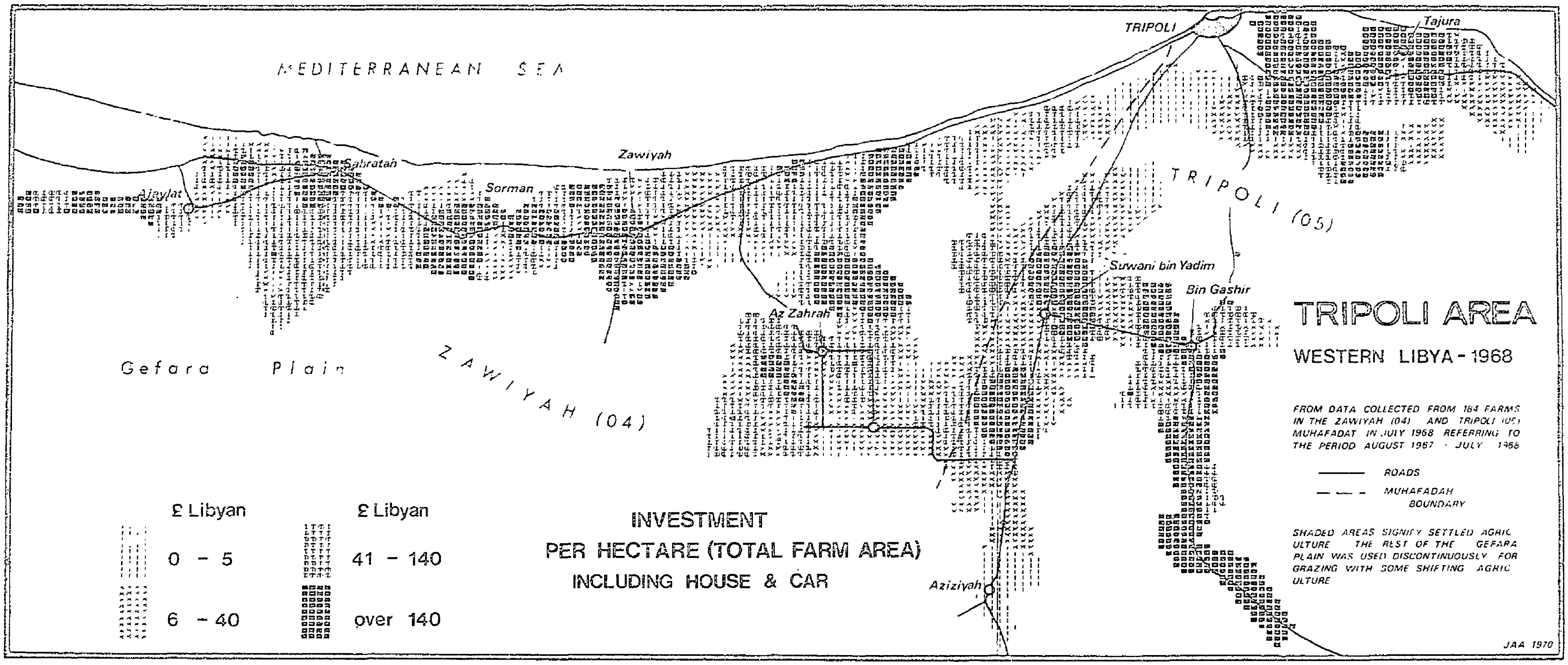

TRIPOLI AREA
WESTERN LIBYA - 1968
FROM DATA COLLECTED FROM 184 FARMS IN THE ZAWIYAH (04) AND TRIPOLI (05) MUHAFADAT IN JULY 1968 REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRIC ULTURE THE REST OF THE GEFARA PLAIN WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRIC ULTURE
INVESTMENT
PER HECTARE (TOTAL FARM AREA)
INCLUDING HOUSE & CAR
£ Libyan
0 - 5
6 - 40
£ Libyan
41 - 140
over 140
MEDITERRANEAN SEA
TRIPOLI
Tajura
TRIPOLI (05)
Suwani bin Yadim
Bin Gashir
Az Zahrah
Aziziyah
Zawiyah
Sorman
Sabratah
Ajaylat
Gefara Plain
ZAWIYAH (04)
JAA 1970

FIG 5.9

reclamation was also given more attention on the 'type 2' farms, accounting for 3% of total investment compared with only 1% on traditional holdings.

It is also interesting to note that the traditional farms were spending more heavily on transport in terms of the total allocation, with 17% going on vehicles of various kinds, mainly private cars. The similar proportion for 'type 2' farms was only 8%, reflecting the higher number of vehicles already available on such farms before the 1967/68 investment year.

The size and sources of loans also indicate differences in the farming types distinguished in this study. Traditional farms received no loans of more than £L 400, while 27% of the larger ex-colonist farms had loans of such a size, with many very much larger since the mean size of loans on such farms was £L 1618, or more than ten times the average figure for traditional farms. The repayment period as might be expected for higher loans was longer on the 'type 2' farm, with a mean figure of 5.9 years, nearly twice the mean figure for traditional farms of 3.2 years.

Enquiries indicated that the source of all major loans was the Agricultural Bank, but the traditional farmers did sometimes resort to other sources and 20% of loans on these farms came from relatives or other sources. All loans on 'type 2' farms came from the Agricultural Bank.

These comments on the pattern of investment in 1967/68 are very revealing of the attitudes of the farmers on the two types of farm, with special reference to investment. Priority was being given to housing and what might be described as items of conspicuous consumption on the traditional farms. There was little attempt to update farming methods or improve land. The allocations on the ex-colonist farms show there to be a strong pressure towards the extension of irrigation and the general improvement and intensification of farming. At the same time we have shown elsewhere that it was upon such farms that there is most scope for such activity in that there was a lower intensity of cropping (in terms of area) and a lower proportion irrigated on the ex-colonist farms than on the traditional holdings. (See Tables 5.9 and 5.10)

It is felt that the preceding discussion confirms that the classification of farm types made for this study was valid in 1968, and further confirmation will be provided through the analysis in the following section by a variety of statistical techniques.

2. Analysis of farm survey data by simple correlation and multivariate techniques

Very similar data to that analysed in the preceding section have been used in this section of the study to further indicate the separateness of the two types of farm already defined as:-

Type 1 Traditional Libyan Holdings

Type 2 Ex-colonist Holdings

In both cases these farms were irrigated or semi-irrigated.

The variables will first be defined, then correlation matrices will be set out and discussed, and finally principal components analyses presented. The purpose will be to identify evidence which confirms or otherwise that there was a quantifiable, separate character, for the two farm types classified for this study.

(2.1) Variable Selection and Definition

From the data collected in the field by questionnaire in July 1968, 19 variables were finally selected. In the process of selection the purpose was to arrange a complex of variables which would through analysis by principal components analysis lead to a comprehensible grouping of the farms. It was hoped that any such groupings would confirm the classification of farm types as defined at the beginning of section 5.3.

A preliminary study was completed in which 32 variables were arranged in a simple correlation matrix. These are listed in Table 5.14. The preliminary study proved useful in determining the variables most strongly related, but it was most valuable in determining the most appropriate level for the expression of the intensity of activity etc. By this is meant whether such features as electric pumps or spray pipes be expressed in terms of the area of the total farm, rather than the area cultivated or the area irrigated. It will be shown that it was found possible to adopt the simple approach of relating all such characteristics to the total area in hectares of the holding.

Nineteen variables were finally selected and entered the 'simple correlation' programme and the 'factor analyses'.

Details of the variable descriptions are given in Appendix 14. It is felt that the brief titles shown in Tables 5.14 - 5.17 are sufficient for other than an extremely detailed examination of the methods and definitions used in this section.

Further it should be noted that all the data enumerated relate to the date of the survey, July 1968, or to the period of twelve months preceding the fieldwork i.e. 1st July 1967 - 1st July 1968. The respondent was the senior member of the household whether he be owner, tenant or manager.

15	Spray pipes per total ha (m)	3.7	7.1	4.2	8.2	13.1	15.6	-	16.2	12
16	Spray pipes per cult'd ha (m)	10.1	19.5	7.7	23.9	36.9	43.9	-	49.2	No
17	Spray pipes per irrig'd ha (m)	11.4	22.2	8.0	27.5	39.1	46.2	-	51.7	No
18	Tractors per total ha	0.011	0.015	0.026	0.011	0.051	0.057	-	0.026	13
19	Tractors per cult'd ha	0.039	0.047	0.046	0.047	0.195	0.170	-	0.159	No
20	Permanent workers per total ha.	0.56	0.57	1.08	0.38	1.01	1.03	-	0.71	14
21	Permanent workers per cult'd ha.	0.15	1.16	1.93	0.87	3.63	2.41	-	1.34	No
22	Permanent workers per irrig'd ha.	0.77	1.35	2.07	1.08	2.14	2.56	-	1.70	No
23	Level of Education (1-5)	1.4	1.5	1.5	1.5	0.8	0.9	-	0.9	15
24	Residents per total ha.	1.21	1.04	2.17	0.62	1.66	1.46	-	0.93	16
25	Residents per cult'd ha.	1.56	2.06	3.51	1.52	2.82	2.79	-	2.07	No
26	Residents per irrig'd ha.	1.93	2.20	4.01	1.60	2.71	2.86	-	2.15	No
27	Total pumps per irrig'd ha.	0.18	0.28	0.39	0.24	0.35	0.37	-	0.34	No
28	Total farm area (ha)	103.2	110.3	14.1	146.2	411.9	410.4	-	476.0	17
29	Mean parcel size	76.0	93.0	4.6	124.6	390.9	405.1	-	471.0	18
30	Total investment*per total ha(£L)	168.5	185.1	296.5	143.4	319.8	325.2	-	272.5	19
31	Total investment per cult'd ha(£L)	279.9	408.8	523.1	345.9	762.5	819.2	-	759.2	No
32	Total investment per irrig'd ha(£L)	315.0	423.1	577.4	385.8	754.5	857.7	-	825.0	No

10. Expenditure (A) = Expenditure on house, new rooms, and building materials
11. Expenditure (B) = Expenditure on car, furniture, wedding and travel

31 &32 Total investment= Expenditure (A) + all other expenditure except on furniture, wedding and travel

Table 5.14

Preliminary and Final List of Variables Subjected to Statistical Analysis

'-' = Not available

No.	VARIABLE NAME	MEAN				STANDARD DEVIATION				VARIABLES ENTERING FACTOR ANALYSIS ETC
		Western	Total Study Area			Western	Total Study Area			
		Libya 371 Farms	All 184 Farms	50 Type 1 Farms	134 Type 2 Farms	Libya 371 Farms	All 184 Farms	50 Type 1 Farms	134 Type 2 Farms	
1	Per cent cultivated	60.2	51.6	57.7	49.3	37.2	36.0	-	37.0	1
2	Per cent cereals	21.5	10.2	10.5	10.1	24.3	16.5	-	14.6	2
3	Per cent vegetables	14.0	18.3	30.2	13.7	23.4	23.1	-	18.6	3
4	Per cent irrigated	31.6	45.7	50.5	43.9	37.4	36.1	-	36.1	4
5	Trees per ha.	48.3	60.2	63.4	59.0	92.9	93.5	-	98.4	No
6	Elec. pumps per total ha.	0.04	0.08	.13	0.06	0.14	0.16	-	0.09	5
7	Diesel pumps per total ha.	0.04	0.06	.14	0.03	0.18	0.20	-	0.11	6
8	Elec. pumps per irrig'd ha.	0.09	0.17	.14	0.18	0.25	0.28	-	0.28	No
9	Diesel pumps per irrig'd ha.	0.09	0.11	.27	0.05	0.29	0.28	-	0.19	No
10	Expenditure (A) per ha (£L)	70.72	62.1	104.7	46.2	203.6	202.4	-	156.8	7
11	Expenditure (B) per ha (£L)	13.7	32.0	92.3	9.5	116.2	118.3	-	32.8	8
12	Rooms per resident	0.8	0.9	0.6	1.0	1.2	1.5	-	1.7	9
13	Length of occupation	14.7	15.1	22.1	12.5	16.2	14.9	-	11.8	10
14	Sheep & goats per total ha.	2.7	1.6	4.0	0.7	7.4	3.3	-	2.1	11

Table 5.14 shows the variables and lists the mean and standard deviation figures for various levels of study and stratification. The position for the overall study of the Western Provinces which comprised 371 farms of both irrigated (and semi-irrigated) and dry farming types. These figures can be compared with the position in the Study Area of the Tripoli Triangle with respect to the 184 farms which were sampled in the muhafadat of Tripoli and Zawiyah. These muhafadat were almost co-terminus with the study area in terms of settled farming. The total 184 farms included both irrigated and semi-irrigated traditional (type 1) and ex-colonist (type 2) farms. A breakdown is given in that details for the ex-colonist (type 2) farms are also listed.

(2.2) Correlation Matrices

Correlation matrices for the three levels of study outlined in the preceding paragraph are shown in Tables 5.15, 5.16 and 5.17.

The examination of the matrices for the 371 farms (Western Libya) and of the 184 farms of the total study area show predictably that the inclusion of the dry farms, mainly on the jabal (hill) areas, in the Western Libya sample has caused the relationships of variables concerned with irrigation (pumps, spray pipes etc) to be less strong in the largest sample including farms in all western Libya. Investment was also less strongly related, or did not figure as significant with respect to variables indicating intensity of activity, such as the percentage of the farm cultivated and workers per hectare.

The correlation matrices for the 184 farms of the total study area and for the 134 ex-colonist farms within that area, when compared, point to a greater homogeneity in the latter sample. Correlation coefficients are everywhere stronger for the 134 farms except for the following explicable situations. Diesel pumps correlate strongly with various types

Table 5.15

Simple Correlation Matrix for 19 Variables. 1968 Data for 371 Farms in Western Libya - Dry & Irrigated Farms Included.

All correlation coefficients shown (i.e. over 0.20) are significant at the 99.9% probability level. 0.172 is the minimum significant value at this level for 371 cases.

		1 Per Cent Cultivated	2 Per Cent Cereals	3 Per Cent Vegetables	4 Per Cent Irrigated	5 Elec. Pumps Per Ha.	6 Diesel Pumps Per Ha.	7 Expenditure (A) Per Ha.	8 Expenditure (B) Per Ha.	9 Rooms Per Resident	10 Length of Occupation	11 Sheep & Goats Per Ha.	12 Spray Pipes Per Ha.	13 Tractors Per Ha.	14 Workers Per Ha.	15 Level of Education	16 Residents Per Ha.	17 Farm Area (Ha)	18 Mean Parcel Size (Ha)	19 Investment Per Ha.
1	Per Cent Cultivated																			
2	" " Cereals	.22																		
3	" " Vegetables	.28																		
4	" " Irrigated	.25		.37																
5	Elec. Pumps Per Ha.			.30	.21															
6	Diesel Pumps Per Ha.			.39	.24															
7	Expenditure(A) Per Ha.						.27													
8	" (B) Per Ha.							.23												
9	Rooms Per Resident																			
10	Length of Occupation																			
11	Sheep & Goats Per Ha.							.32	.28											
12	Spray Pipes Per Ha.					.37														
13	Tractors Per Ha.					.23														
14	Workers Per Ha.			.46			.23	.35	.39		.26									
15	Level of Education			Neg .25						.37										
16	Residents Per Ha.	.21		.44	.21		.38	.41	.41		.22	.35			.71	Neg .22				
17	Farm Area (Ha)									.31						.21				
18	Mean Parcel Size (Ha)									.31								.96		
19	Investment Per Ha.			.20				.80	.41			.32			.36		.42			

Ha. = Hectare/s

Expenditure (A) = Expenditure on house, new rooms, and building materials

Expenditure (B) = Expenditure on car, furniture, wedding and travel

Investment = Total farm investment (i.e. expenditure (A) + all other expenditure except furniture, wedding, travel)

Source: LULUJRP data for 371 farms in Western Libya - July 1968

Table 5.16

Simple Correlation Matrix for 19 Variables. 1968 Data for 184 Farms in the Tripoli Study Area - Irrigated and Semi-irrigated Farms Both Traditional & Ex-colonist. (Types 1 & 2)

All correlation coefficients shown (i.e. over 0.23) are significant at the 99.9% probability level.

		Per Cent Cultivated	Per Cent Cereals	Per Cent Vegetables	Per Cent Irrigated	Elec. Pumps Per Ha.	Diesel Pumps Per Ha.	Expenditure (A) Per Ha.	Expenditure (B) Per Ha.	Rooms Per Resident	Length of Occupation	Sheep & Goats Per Ha.	Spray Pipes Per Ha.	Tractors Per Ha.	Workers Per Ha.	Level of Education	Residents Per Ha.	Farm Area (Ha)	Mean Parcel Size (Ha)	Investment Per Ha.
1	Per Cent Cultivated																			
2	" " Cereals																			
3	" " Vegetables	.25																		
4	" " Irrigated	.32		.39																
5	Elec. Pumps Per Ha.			.36	.22															
6	Diesel Pumps Per Ha.			.49	.23															
7	Expenditure (A) Per Ha.			.24	.20		.40													
8	" (B) Per Ha.							.24												
9	Rooms Per Resident																			
10	Length of Occupation					.25														
11	Sheep & Goats Per Ha.			.30			.34		.38											
12	Spray Pipes Per Ha.			.17		.33														
13	Tractors Per Ha.					.25					.22									
14	Workers Per Ha.			.45	.19		.29	.40	.57		.20	.29								
15	Level of Education			Neg .24						.42										
16	Residents Per Ha.			.53	.21	.31	.50	.44	.50		.19	.50			.69					
17	Farm Area (Ha)			Neg .19	Neg .19					.30						.21	Neg .18			
18	Mean Parcel Size (Ha)									.28								.98		
19	Investment Per Ha.	.24		.31	.24		.26	.79	.39			.31			.43		.47			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Ha. = Hectare's

Expenditure (A) = Expenditure on house, new rooms, and building materials

Expenditure (B) = Expenditure on car, furniture, wedding and travel

Investment = Total farm investment (i.e. expenditure (A) + all other expenditure except furniture, wedding, travel

Source: LULUJRP data for 184 farms in Western Libya - Areas 04 & 05, Zawiyah and Tripoli Muhafadat, 1968

Table 5.17

Simple Correlation Matrix for 19 Variables. 1968 Data for 134 Farms in the Tripoli Study Area - Irrigated and Semi-Irrigated Ex-colonist Farms (Type 2)

All correlation coefficients shown (i.e. over 0.28) are significant at the 99.9% probability level.

		1 Per Cent Cultivated	2 Per Cent Cereals	3 Per Cent Vegetables	4 Per Cent Irrigated	5 Elec. Pumps Per Ha.	6 Diesel Pumps Per Ha.	7 Expenditure (A) Per Ha.	8 Expenditure (B) Per Ha.	9 Rooms Per Resident	10 Length of Occupation	11 Sheep & Goats Per Ha.	12 Spray Pipes Per Ha.	13 Tractors Per Ha.	14 Workers Per Ha.	15 Level of Education	16 Residents Per Ha.	17 Farm Area (Ha)	18 Mean Parcel Size (Ha)	19 Investment Per Ha.
1	Per Cent Cultivated																			
2	Per Cent Cereals	.22																		
3	" " Vegetables	.24																		
4	" " Irrigated	.31		.29																
5	Elec. Pumps Per Ha.			.44	.24															
6	Diesel Pumps Per Ha.			.56	.17															
7	Expenditure (A) Per Ha.		.33	.18	.21		.17													
8	" (B) Per Ha.		.30					.48												
9	Rooms Per Resident	.17																		
10	Length of Occupation						.26			.20										
11	Sheep & Goats Per Ha.			.23		.17	.18		.27											
12	Spray Pipes Per Ha.			.21		.48														
13	Tractors Per Ha.	.17			.28				.22		.16									
14	Workers Per Ha.			.56	.19	.34	.65	.17			.17		.23							
15	Level of Education			Neg .28		Neg .17				.43					Neg .22					
16	Residents Per Ha.			.59		.44	.60	.30		Neg .21		.32	.33		.86	Neg .25				
17	Farm Area (Ha)			Neg .19	Neg .21	Neg .17				.29						.20	Neg .19			
18	Mean Parcel Size (Ha)			Neg .17	Neg .18	Neg .15				.27						.17	Neg .18	.98		
19	Investment Per Ha.	.27	.37	.34	.25	.18		.79	.52			.22		.25	.20		.33			

Ha. = Hectare/s
Expenditure (A) = Expenditure on house, new rooms, & building materials
Expenditure (B) = Expenditure on car, furniture, wedding & travel
Investment = Total Farm Investment (i.e. expenditure (A) + all other expenditure, except furniture, wedding, travel)

Source: LULUJRP data for 134 farms in Western Libya - Areas 04 & 05, Zawiyah and Tripoli Muhafadat, 1968.

of expenditure and investment in the total sample, but not at all on the ex-colonist farms, because the possession of diesel pumps was a feature of the 50 traditional farms. In Table 5.14 it is shown that diesel pumps were more than five times as numerous on 'type 1' farms as on 'type 2'.

The intensity of activity on both types of farm was also shown to be distinguishable in terms of labour and residents and their correlations with irrigation variables (e.g. spray pipes per hectare), livestock and level of education. It was the 'type 2' farm which showed as having the stronger inverse relationship between education and worker as well as residential density, reflecting partly the very much larger range in size of the 'type 2' farms. The very much higher livestock population on the 'type 1' farms (Table 5.14) also reflected in the very much higher relationship of this variable with labour and residents expressed in terms of the area of the farm.

Another feature of irrigation which points to a difference in the management, at least, of the two types of farm is the correlation of diesel pumps per hectare with the length of occupation on 'type 2' farms. This does not mean that such pumps were more numerous than on the traditional farms (Table 5.14 shows the contrary), but that those who had occupied such farms longest, that is Italian farmers, were still using diesel equipment acquired before electrification or for other reasons preferred diesel pumps and had acquired them more recently. The newer occupants of the 'type 2' farms had in almost all cases installed electric pumps. It is also relevant to note that on these ex-colonist farms electric pump intensity was more closely correlated with vegetable raising than on 'type 1' farms.

Vegetable growing was, however, more consistently represented on 'type 1' farms than on the ex-colonist holdings. A high proportion of irrigated land points strongly to a high proportion under vegetables on the traditional holdings. On ex-colonist holdings this was not the case, reflecting the greater attention given to other irrigated crops, such as alfalfa, melons and ground-nuts. This is a pattern confirmed by the crop surveys carried out by the Joint Project.[27]

(2.3) Principal Components Analysis

The variables were entered into a factor analysis 'package' and a number of solutions obtained in terms of the number of factors specified. The analyses were completed first for the whole sample to determine whether the traditional and ex-colonist farms could be shown to be different by this method of analysis, and secondly for the 134 ex-colonist farms to establish whether farms with markedly different sets of farm characteristics could be identified within this 'stratification'.

These principal components analyses were used in both cases to try to improve the mathematical model and provide a readily comprehensible explanation of the large number of operational variables. The technique is used in problems where it is thought that variables will be clustered, in the sense that, within any given cluster of indices there will be high inter-correlations, whereas correlations between clusters will be low. For example in this study it was anticipated that inter-correlation between irrigation variables and variables related to intensive farming along with high densities of labour and residents would be revealed by such analyses.

The technique is treated in detail in Harman,[28] Cattell[29] and King.[30] The method used here is similar to that used by Ahmad.[31] Instead of employing all the components only a few which can be regarded as meaningful have been adopted. In addition the components were rotated orthogonally to give a 'varimax' component solution.

A number of criteria have been proposed with reference to the optimal selection of components. It was suggested by King[32] that all components with eigenvalues equal to or greater than one be evaluated. Alternatively he advocated treating those components which account for at least 5% of the total variance. Adelman and Morris[33] are doubtful whether any solution which accounts for less than 65% of the total variance in the data matrix should be accepted. These three criteria were borne in mind but at the same time it was considered important that ease of interpretation be an additional consideration. In practice little difficulty was experienced in this study in naming components each with a separate character. It should be added that solutions with more and less than six components were run but were found to be less easy of interpretation. The six component solutions were adopted for the total sample and the 134 ex-colonist farms.

In examining the two sets of indicators (eigenvalues and communalities) which are available for the assessment of a principal components solution for the total sample (184 farms both traditional and ex-colonist) it can be seen first from Table 5.18 that the six component solution comprises components with an eigenvalue* of 1.87, each of which account for just over 6% of total variance.** Although only 60% of the total variance is accounted by the solution, in other respects, i.e. the 6% accounted of each component, the high eigenvalue of the first component and the ease of interpretation, make it possible to accept the solution as evidence of the clustering of variables in an explicable way.

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* Eigenvalue may be more precisely defined as the simple root of the characteristic equation. When summed eigenvalues give a value of 22.0 which is the trace of the sum of the principal diagonal of the correlation matrix.

** (60% - 23%) ÷ 6 = 6.17%

SUMMARY OF COMPONENT LOADING MATRIX

Total Study Area - Traditional & Modern Farms

All Farms Irrigated or Semi-irrigated

Sample Size 184 Farms

Six Factor Solution

	COMPONENTS					
	I	II	III	IV	V	VI
	Traditional gardens spending & investing heavily on small holdings	Traditional gardens - lacking modern electrified irrigation	Ex-colonist farms - neglected	Traditional gardens - intensively irrigated	Ex-colonist farms - high standard of living	Both Farm Types - highly mechanised
EIGENVALUE	7.21	3.10	2.71	2.34	2.11	1.87
Cum % of Variables for which this factor is best fit	23	32	41	48	54	60
	Perm.workers/total ha. .80 Residents/total ha. .59 Invest(*)/total ha. .71 Expend(B)/total ha. .70 " (A)/ " " .56	Spray pipes/total ha. - .82 Elec.pumps/total ha. - .71	Diesel pumps/ total ha. - .84 % vegetables - .53 Residents/total ha. - .49	% irrigated .67 % cultivated .63 Trees per ha. .45 % vegetables .44 Length of occupation .43 Invest(*)/total ha. .35	Mean farm size .89 " parcel size .88 Rooms/resident .59 Level of Education .46	Tractors/total ha. .72

Note. Expenditure (A) - on house, new rooms and building materials
" (B) - on car, furniture, wedding & travel
Investment (*) - Total investment on Farm less that on furniture, wedding & travel

Source: Selected data from LULUJRP survey 1967/68 - Areas 4 & 5 Tripoli and Zawiyah.

Table 5.19

Communalities

for

Total Study Area & Ex-colonist Farms

Variable	Communality		Variable Description
	Total Sample 184 Farms	Ex-colonist 134 Farms	
1	.55	.56	% cultivated
2	.02	.29	% cereals
3	.62	.57	% vegetables
4	.47	.61	% irrigated
5	.54	.57	Electric pumps per hectare
6	.79	.70	Diesel pumps per hectare
7	.45	.57	Expenditure (A) per hectare
8	.55	.50	Expenditure (B) per hectare
9	.41	.47	Rooms per resident
10	.23	.25	Length of occupation
11	.31	.22	Sheep and goats per hectare
12	.74	.80	Spray pipes per hectare
13	.61	.47	Tractors per hectare
14	.77	.84	Workers per hectare
15	.73	.81	Level of Education
16	.72	.74	Residents per hectare
17	.85	.71	Farm area (hectares)
18	.82	.67	Mean parcel size
19	.59	.78	Investment per hectare

The second set of indicators, that of the communalities, appear in Table 5.19. These are measures of the proportion of the total variation in a variable which has been accounted by the principal component solution. Three variables appear at levels which might be considered redundant (i.e. below 0.35). However, one of these 'length of occupation' does contribute to Component IV in Table 5.18 in a coherent way. Further three other variables have communalities below 0.50. All of these three variables, however, contribute to the explanation provided in Table 5.18, and have therefore been retained.

It is not proposed to discuss the component loading matrix, (a summary of which is shown in Table 5.18) in great detail. The matrix was prepared with a view to illustrating the separateness of two types of farm, and it is felt that the table performs this function without further treatment. Three components have been named which represent groupings of variables which have elsewhere been associated with 'type 1' traditional farms, i.e. Components I, II & IV. Components III & V are concerned with ex-colonist farms. Component VI is associated with mechanisation in terms of tractors. There was inter-relationship with investment but not at a high level. Mechanisation as seen elsewhere in section 5.3.1(1) was most intensive (i.e. tractors per hectare) on the smaller farms of the ex-colonist type, and the larger of the traditional holdings. This mechanisation component is associated therefore with both farm types.

Finally to look at the principal components analysis with respect to the ex-colonist modern farms (Table 5.20). In terms of eigenvalues and accounting for the total variance in the sample of ex-colonist farms, this second principal components analysis compares closely with the analysis for the total study. The eigenvalue is 1.93 and 62% of the variance is accounted, with over 6% of this by each component.

Table 5.20

SUMMARY OF COMPONENT LOADING MATRIX

Ex-colonist 'Modern' Farms Only

All Farms Irrigated or Semi-irrigated

Sample Size 134 Farms

Six Factor Solution

	COMPONENTS					
	I	II	III	IV	V	VI
					Large ex-colonist Farms	
	High labour & population density (Probably newly acquired & small)	Neglected Farms	High level of Investment. Probably newly acquired & small	Neglected Farms	Large Farms -high standard of living	Mechanised Farms run by pre-independence owners
EIGENVALUE	6.77	3.48	3.10	2.35	2.12	1.93
Cum.% of Variables for which this Factor is Best Fit	21	32	42	49	56	62
	Perm workers / total ha. .88 Residents/ total ha. .81 Diesel pumps/ total ha. .78	Inv(*)/total ha -.85 Expend(A)/ " -.74 " (B)/ " -.69 % cereals -.53 % cultivated -.44 Sheep etc/ total ha. -.33	% cultivated .78 Inv(*)/ total ha. .72	Spray pipes/ total ha. -.87 Elec.pumps/ total ha. -.64 Length of occupation+.30	Mean farm area .81 Mean parcel size .80 Rooms/resident .59 Level of education .47	% irrigated .73 Tractors/ total ha. .58 Trees/ha. .58 Length of occupation .28

Note Expenditure (A) - on house, new rooms & building materials
" (B) - on car, furniture, wedding & travel
Investment (*) - Total investment on Farm less that on furniture, wedding & travel

Source: Selected data from LULUJRP survey 1967/68 - Areas 4 & 5 Tripoli & Zawiyah

It is only important to note that apparently neglected farms were identified in Components II & IV. Such a position was observed in the field where Italian owners had allowed their farms to run down, or where recently purchased large farms were not being used by their owner for agricultural purposes. Other groupings were associated with high intensities of labour, residents and irrigation (Component I) and heavy investment. These were almost certainly the newly acquired and much sub-divided ex-colonist farms, as recorded in earlier discussions of the Talbighah and Suwani bin Yadim areas. Other characteristics were present to cause the grouping in Component V and VI where the higher standard of living usual on many of the largest ex-colonist farms and their dependence on mechanised methods have been emphasised.

5.3.2 Case Studies Illustrating the Trend Towards an Intermingling of Characteristic Farming Methods in the Tripoli Triangle.

The preceding section (5.3.1) has been prepared with a view to establishing that a difference existed between traditional and ex-colonist farms in 1968. As this analysis was being completed, however, evidence began to emerge that some features which could be quantified on ex-colonist farms were very similar to patterns of activity on farms which have been classified as traditional. For example, Components I & III from Table 5.20 relating to 'type 2' farms indicate a pattern of activity very similar to that characteristic of 'type 1' traditional gardens (see Table 5.18, Components I & IV). Such evidence will be reviewed first and then some case studies based on photogrammetric analyses will be presented.

In section 5.1, and especially in sub-section 5.1.3 it was established that there had been a considerable intensification of irrigated farming on ex-colonist farms, both in areas adjacent to traditional gardens and in some more than 20 kilometres distant, for example at Suwani bin Yadim.

Two factors only will be examined with special reference to the newly acquired farms; first farm size and secondly irrigation methods.

Subdivision rather than amalgamation was the rule on the farms acquired since independence, and especially after oil. For example the SACIA ex-concession was over 600 hectares in 1950. By 1955 it was being managed as three units, with less than 400 hectares controlled by the original owners. Further sales of land took place in the early 1960s, so that by 1968 only 180 hectares of the original holding remained. (See Fig 5.5). The mean size of holding has therefore been progressively reduced, and by 1968 approximately one third of the original concession was being managed as holdings averaging less than three hectares. (See Fig 5.5 area recorded as 'Small Libyan Owned Farms'). Such a farm size much more resembled the farm units which thus far in this study have been classified as traditional 'type 1' traditional holdings. It is much smaller even than the mean farm size recorded in Table 5.14 for the 50 sampled farms of the traditional type in the 1968 survey for the Tripoli triangle, but does compare closely with mean farm size of type 1 farms as recorded in Table 5.9, i.e. 4.0 hectares. The latter figure was derived from the sample traditional farms from all of western Libya.

Elsewhere there was much evidence that relatively small farms were becoming common. Holdings were small whether created through purchase for example at Talbighah, or through the extension of irrigation into previously unused areas, for example 'South of

Sabratah' and 'West of Ajaylat'.

The principal components analysis in section 5.3.1(2.3) did allow these relatively small intensively organised holdings to be identified. Table 5.20 draws attention to those ex-colonist farms which were densely populated, relatively intensively irrigated with a high proportion cultivated and much farm investment in progress in 1967/68. (Components I & III)

In terms of farm size therefore, it has been possible to identify a group of farms which when examined further can be shown to have had different characteristics from the rest of the ex-colonist farms. The latter might be relatively neglected (Components II & IV Table 5.20) or highly mechanised and frequently had owners with a high standard of living. Extensive fieldwork and examination of air photographs of the 'Tripoli Triangle' showed that the recently purchased/acquired small farms were widely dispersed. They existed close to Tripoli, both east and south-west of the city within 10 kilometres of the centre, but also in more distant areas such as Bin Gashir and Suwani bin Yadim and beyond, and also in the extreme west of the total study area.

This very dispersed group of farms was similar in size therefore to traditional type 1 farms, and able to be distinguished from the other ex-colonist farms, both those which were neglected and those being farmed effectively. In numerical terms the group was estimated to comprise more than half of the ex-colonist farms, although in area such farms accounted for only 20% of the total area covered by ex-colonist holdings.

In terms of the second factor, that of irrigation methods, these small and newly founded ex-colonist farms,* were also what may

* In this paragraph we are not discussing the newly founded farms on previously unused areas such as South of Sabratah etc. in the west of the study area.

be described as 'transitional'. A 'modern' layout was often inherited, sometimes with underground pipes for distributing water.

The new owners, however, often brought methods used by them on their previous, traditionally run holdings. It was not uncommon therefore to find basin methods being used beneath the regularly planted olive groves of a subdivided ex-colonist farm. These relatively small farms were also characterised by cropping patterns very similar to those of traditional gardens, with very small plots of particular crops, possibly only a few square metres in extent, for example at Talbighah.[34]

At the same time some methods symptomatic of progressive farming had been incorporated on some of the traditional 'type 1' holdings. The contention here is, therefore, that although one could continue to justify statistically the distinction between traditional and ex-colonist farms, such distinctions were becoming blurred. Traditional farms, where they were not turned over to a residential function were experiencing investment and innovation, and this meant that they were not very different in character from the usually small, and newly purchased ex-colonist holdings.

The process of subdivision by purchase was observed to be an on-going process, assisted in some cases by the loans available from the agricultural authorities, and in the absence of a strong government policy to the contrary, it seemed likely that the area of smaller holdings of the modified ex-colonist type would continue to be extended.

This discussion has proceeded without reference to government sponsored farms. The settlement authority of the Ministry of Agriculture was responsible for a number of enterprises in the study area. In general their policy was not dissimilar in its outcome from that of private development. In terms of farm size similar units were being developed. Possibly they could be distinguished from the private holdings in the intensity of cropping,[35] reflecting the guidance of the extension service but also a generally subsidised situation.

The preceding evidence establishes the transitional character of the smaller ex-colonist farms, and the foundation and spread of such holdings might be regarded as a trend which will involve an increasing proportion of the 'Tripoli Triangle'. A considerable pressure was observed during fieldwork on land, with many land sales imminent by Italian owners to prospective Libyan buyers. In addition, those who had already purchased holdings regarded themselves as permanently settled. This was strongly indicated by the questions in the questionnaire relating to migration. No farmers questioned had any intention of leaving their farms.[36]

The farms which we have distinguished as a 'transitional' type in terms of agricultural development would on this evidence appear likely to become the 'normal' type of farm in the study area, even if government intervention, or serious underground water problems seem likely to intervene to interrupt the process of change.

In conclusion we can re-iterate the findings of the three sections of this chapter. In section 5.1 it was established that agriculture had become more intensive by 1968 than pre-oil, on ex-colonist farms, certainly in terms of the area cropped and investment per hectare and such developments were associated with increases in output. In addition it has been shown in section 5.3 that many previously unused areas have been taken over as farms, normally of the irrigated or semi-irrigated type.

In the final section, section 5.3, after confirming that the traditional farms could still be satisfactorily identified in 1968, it was next shown that this distinctiveness was being modified. The newest holdings, those established since oil, were small, often being less than four hectares in size, and this feature together with other variables concerned with farming practice and direction of investment made such new, ex-colonist farms, similar to the traditional farms, and reflected the origins of the owners of these newly acquired holdings.

In the next chapter the problems of continuing such developments will be examined with respect to the main physical, economic and institutional constraints.

CHAPTER 6

PHYSICAL AND ECONOMIC FACTORS ACTING AGAINST THE FURTHER EXTENSION OF IRRIGATED AGRICULTURE IN THE STUDY AREA

It has been very thoroughly established that irrigated farming was expanding and intensifying in the study area in 1968. It has also been illustrated that a particular type of private farm enterprise* had been mainly responsible for such development, while at the same time government sponsored schemes** were also being developed or researched on the basis of irrigated farming.

6.1 The Inadequacy of Underground Water Resources

It will be the purpose in this section to present evidence quantifying the decline of underground water levels in the study area especially in the areas of detailed study, Suwani bin Yadim and Talbighah. Most of the data presented are original and were collected during my stay in Libya, which extended over two years (1967-68). Because of the seasonal movements in the level of underground water it was necessary to take records over a whole year.

An explanation of the methods used in the field to record precise ground levels and water levels, with reference to a sea-level datum are given in Appendix 6.2.

Having defined the extent of the decline in underground water, the implications of this decline will be examined in the final part of the part of the chapter. These implications relate to the

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* See Chapter 5.3.2

** For example Sa'a'idiyah in the study area. It should be noted that the Hab al Khadrah scheme, although a government irrigation scheme and within the study area, was planned on the basis of water supplies from purified Tripoli sewage.

exhaustion of the aquifers, to increasing irrigation costs, and to the possibility of disturbing seriously the salt-fresh water equilibrium at the coast, leading to salt water intrusion into the aquifers.

6.1.1 The Importance of underground water

It has been shown that rainfall in north west Libya is unreliable and often insufficient even for the winter field crops of the study area. (see Section 4.1.2 and 4.1.4) Summer field crops require regular irrigation. Similarly tree crops often need soil moisture recharge from a sure irrigation source, and others, especially citrus, may need supplementary watering in winter.

Table 6.1.1 [1,2,& 3] lists a number of Mediterranean field crops, and indicates their approximate water requirements in the Mediterranean environment. The average water requirement would appear to be 12,000 cubic metres per year, which is the figure also used by Cederstrom,[4] for the sandy soils of Libya.

TABLE 6.1.1

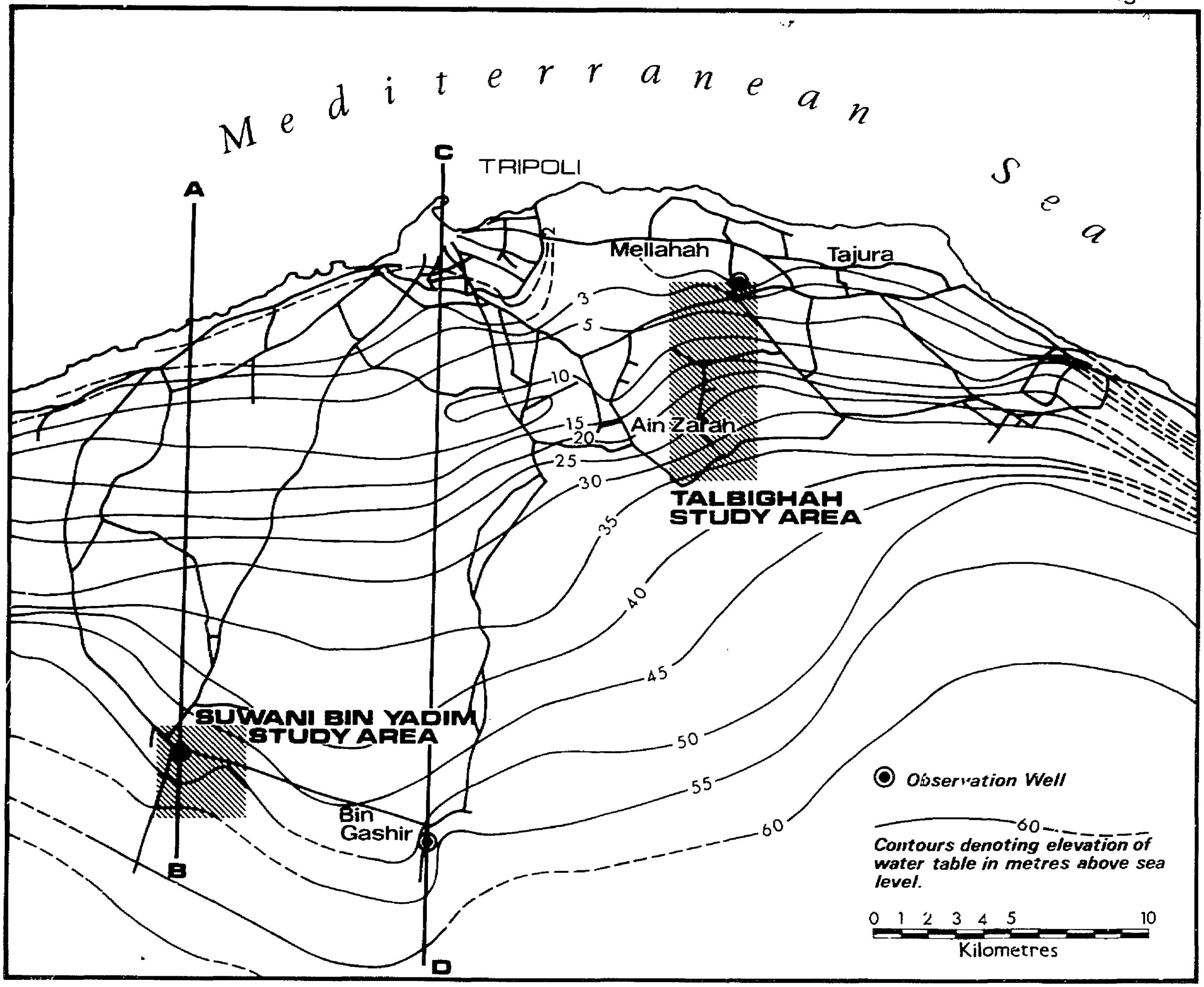
The Growing Season and Water Requirements of a Number of Irrigated Crops

Crop	Growing Season in Months	Supposed Water Requirement in cm./Month	Total For The Season	Total Per Hectare m^3
Orchards[2] (including citrus)	12	11	1.32	13,200
Alfalfa (safsa) - (summer)[3]	5	25	1.25	12,500
Tobacco[1]	5	19	.95	9,500
Tomatoes (summer)[1]	5	36	1.86	18,600
Groundnuts[1]	4.5	25	1.13	11,300
Melons[1]	3.5	27	0.95	9,500
Potatoes[1]	3	17	.51	5,100
Potatoes[2]	3	30	.90	9,000

Sources: The above figures are drawn from data for a number of Mediterranean and Middle Eastern countries.[1,2 & 3]

Fig 6.1.1

Fig. 6.1.1



ELEVATION OF THE WATER-TABLE IN 1959

Source: Cederstrom D.J & Bertaiola M, Ground Water Resources of the Tripoli Area, Tripoli, 1960, Fig. 14

Such potential requirements should be viewed against the possible recharge of the aquifers, the only source of irrigation water in coastal Libya. At Talbighah there was a small recharge from precipitation falling in the area (See Chapter 4, Table 4.2.2) but it is clear that almost all the 12,000 cubic metres of water per hectare for irrigation was drawn from storage, or from water flowing underground into the area from outside. It is probable that only 10 mm. from total precipitation reaches the groundwater reservoir as estimated by Stewart,[5] that is 5% of the average rainfall for the agricultural zone of the Gefara (24,570 square kilometres). If all this water was successfully absorbed into the underground system, recharge should bring ground-water levels back each winter to the level of the previous winter. It will be shown, however, that throughout the study area the annual trend in groundwater levels was downwards, indicating that either underground water was escaping to the sea, or that much less than the above calculated quantity reached the ground-water reservoir, or otherwise that usage was significantly higher than the rate of recharge. Evidence will be presented which will establish that it was excessive usage which was causing the decline in underground water levels.

6.1.2 Decline of Underground Water Levels at Suwani bin Yadim

The evidence for declining underground water levels at Suwani bin Yadim is shown in Table 6.1.2

TABLE 6.1.2

Declining Water Levels at Suwani bin Yadim

(see Fig 4.22)	Location	Readings in metres in March			Average decline per year in metres
		1956	1959	1968	
822	1km. SE Suwani'	18.0	-	24.4	0.49
819	½km. N. Suwani'	15.6	-	21.3	0.44
3242-1302-1	Suwani bin Yadim	-	11.4	16.2	0.48

Sources: 1956 readings Cederstrom & Bertaiola
1959 readings Ministry of Agriculture, Soil and Water Conservation Department
1968 readings - 822 & 819 by author
- 3242-1302-1 by Soil and Water Conservation Department.

That the water was lowered each year on average by half a metre in 1968 was serious enough, but when the rate of decline can be demonstrated to have been increasing, (see Fig 4.2.3 and Appendix 7.1) the long run danger to agriculture in the Suwani bin Yadim area is clear.

There was a marked increase in the rate of decline in the 1963-1964 period. This is shown on the diagram (Fig 4.2.3) and also in the attempt to fit a simple regression line to the time series (Fig 6.1.2). The form of the residuals indicates clearly that there had been a marked increase in the rate of decline since the middle of the time series. The point at which the rate of decline increased can be attributed to the introduction of many new electric pumps, which occurred after 1961, when increased agricultural investment followed the beginning of oil revenues in Libya. Certainly by the time my questionnaires were carried out in 1967 all the farms in the area either had electric pumps, or had access to water raised by such a pump.

The increased rate of withdrawal, and falling water levels brought about the need to deepen wells regularly. Most farmers had had their wells redrilled, and some realised that the water was falling one metre per year by 1968,* since they had to deepen their wells by this amount each year. (Figure 6.1.3)

The cost of deepening wells must be added to the already increasing running costs of raising water from greater depths. Deepening a well, if done by a contractor can cost £L 20 per metre. Unfortunately no studies have been done in the recent past concerning Libyan irrigation costs, and these would be difficult in any event as electricity for agricultural use is heavily subsidised.

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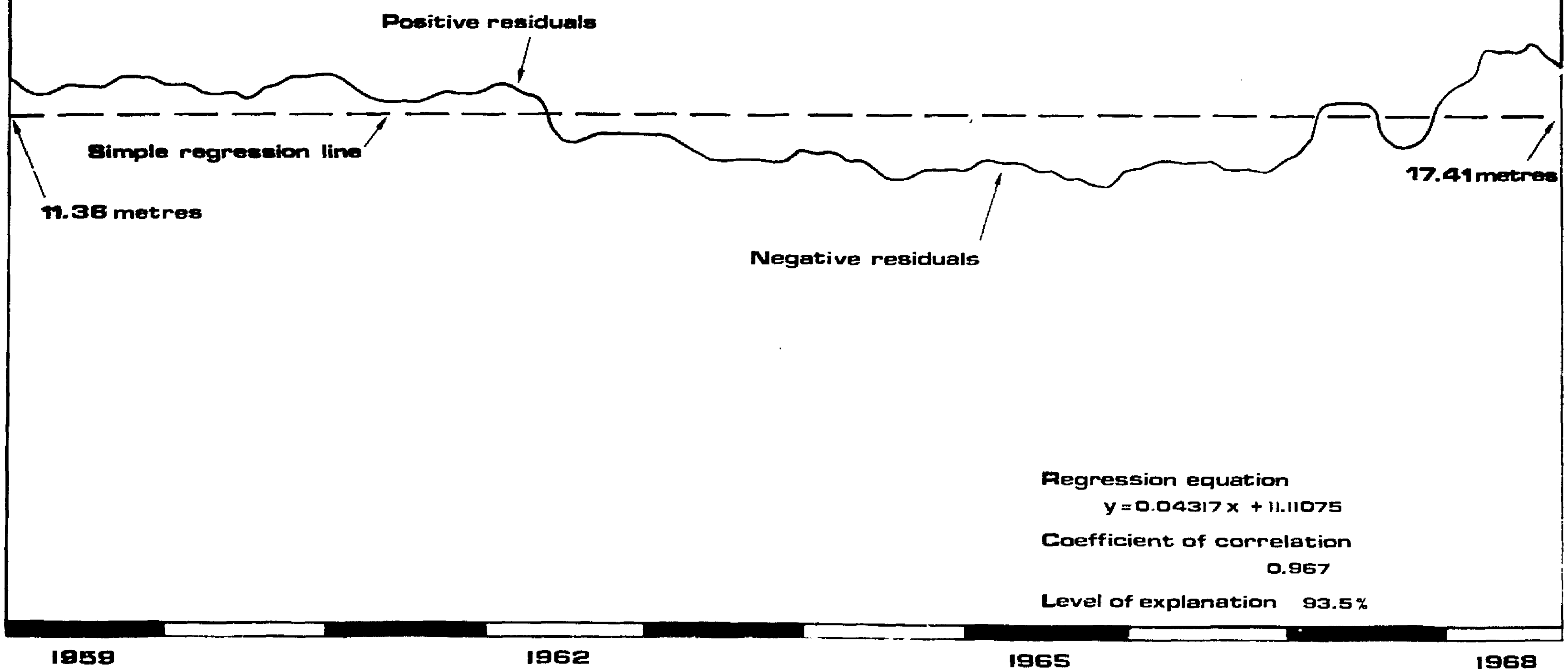
* Visits to Suwani bin Yadim in 1970 and 1971 permitted further observation and records. By the summer of 1971 the rate of decline in underground water levels had increased to two metres per year in Suwani bin Yadim.

FIG 6.1.2

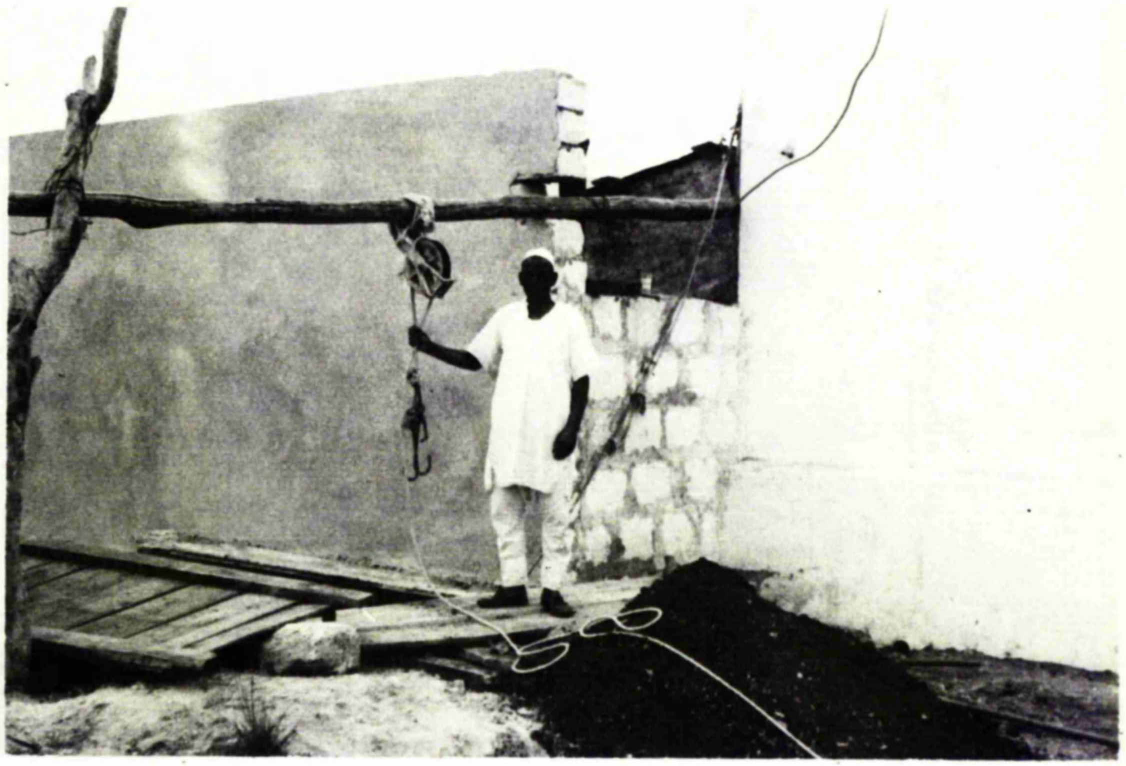
SEASONAL MOVEMENTS OF THE WATER TABLE SUWANI BIN YADIM

A regression line and residuals, demonstrating the increasing rate of decline.



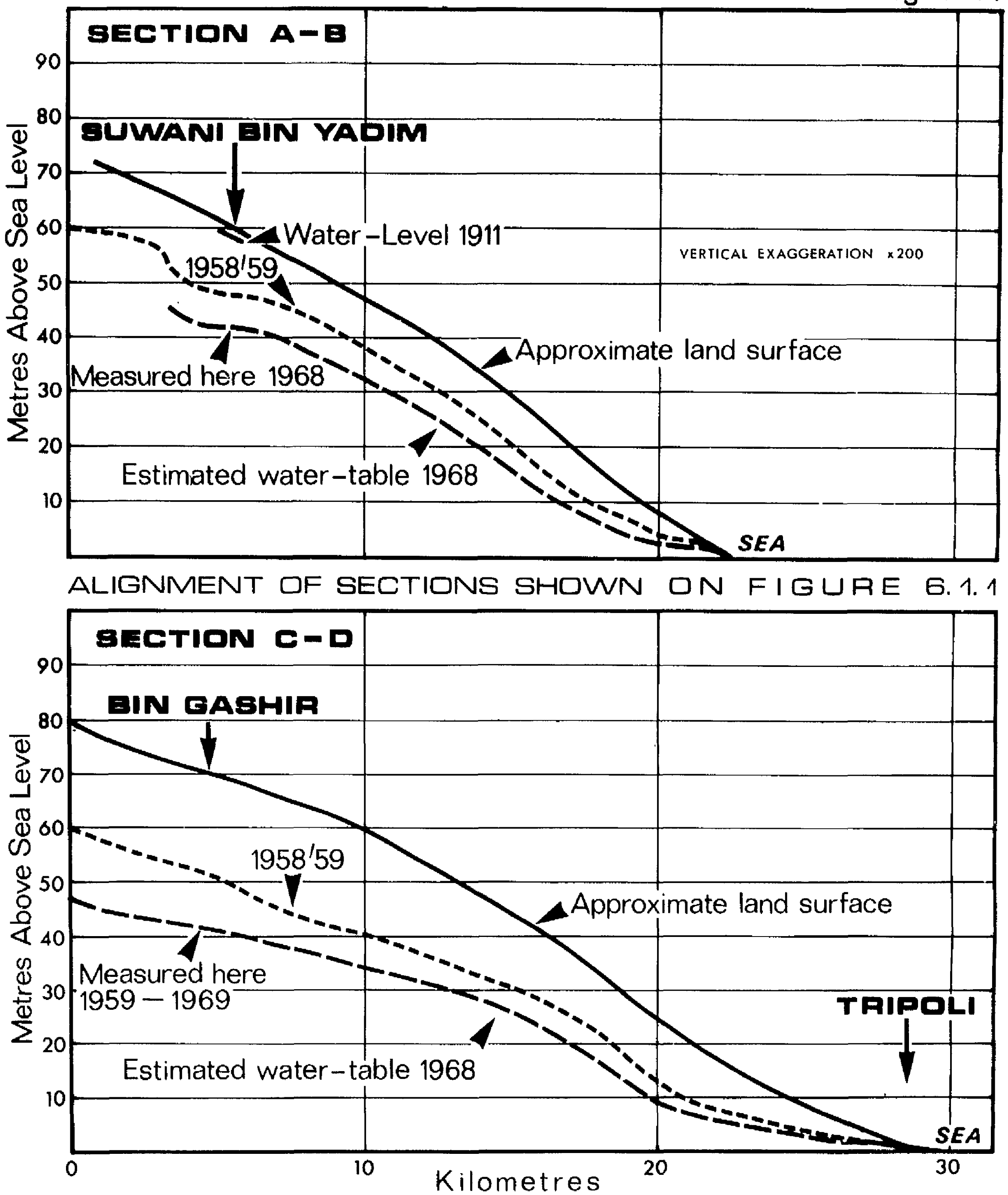
Source: Soil and Water Conservation Department, Data for Observation Well 3242·1302·1

FIG 6.1.3



Farmer at Suwani bin Yadim beside a well which he had just deepened in order to keep pace with declining ground water levels. July 1968

Fig. 6.1.4



Sections Showing the Scale of the Decline in Underground Water Levels Between Suwani bin Yadim and Bin Gashir and the Coast

Source: **Figure 6.1.1 and field measurement by the author with Soil and Water Conservation Department data for observation wells at Suwani bin Yadim and Bin Gashir.**

Engineers usually calculate[6] that 0.00644 KW of electricity are required to pump one cubic metre of water from a depth of one metre. Clark (1967) indicates that water costs increase in direct proportion with depth.[7] Thus at Suwani bin Yadim water costs can be expected to increase by 25% in five years, even if the rate of decline in groundwater levels does not increase.

6.1.3 Decline of underground water levels at Talbighah

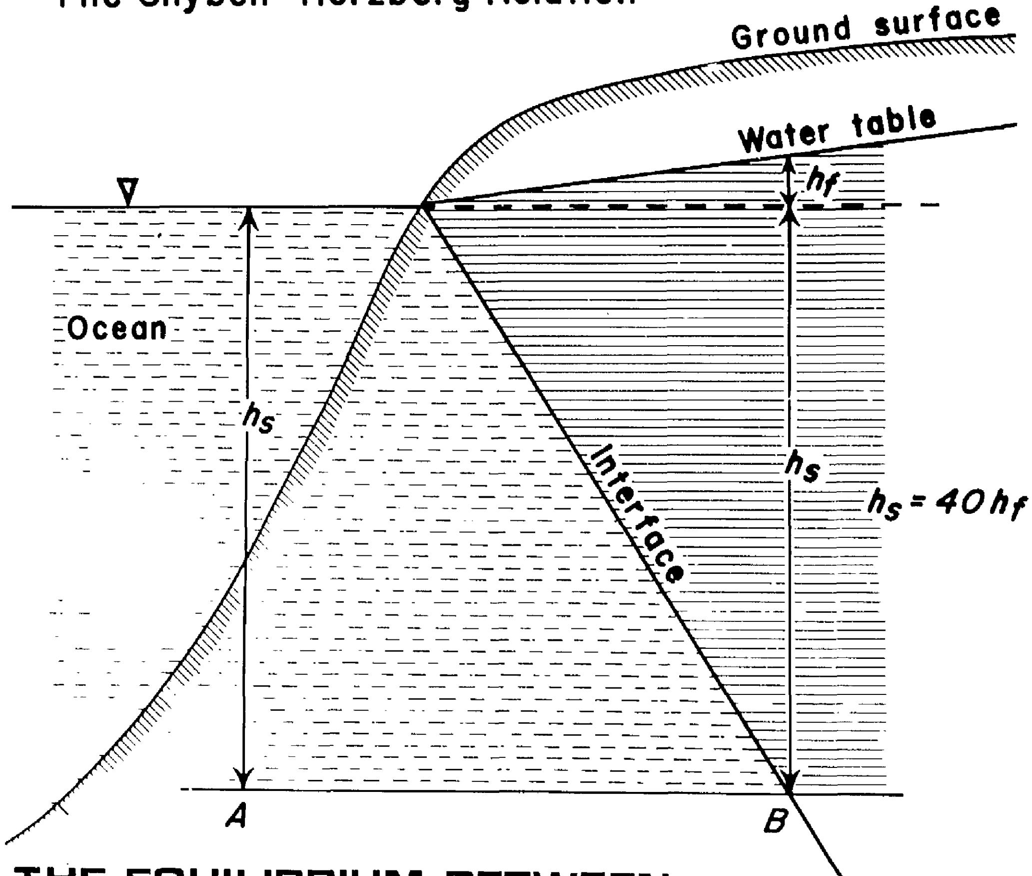
Talbighah is less obviously affected by water supply difficulties. The level of underground water for a well close to the north-east corner of the area is illustrated in Fig 4.2.3, and shows that since 1960 there has been only a small decline in levels. This well is only two kilometres from the coast. However, the laws governing the movement of water near the coast show that declines in water levels will be less near the sea and the 'hinge-line'. (Fig 6.1.5)

Groundwater beneath the Gefara Plain flows north to the coast, down a gradient similar to, but less than that of the land surface. The depth of groundwater beneath the surface is shown for Talbighah in Fig 6.1.7. These diagrams were possible to compile because I was able to have special maps drawn showing accurate levels above sea level. In order to carry out this survey it was necessary to have aerial photography flown to give stereoscopic cover, and then to provide ground control so that photogrammetric work could be completed later, in London. Details of the aerial photography and ground control are given in Appendix 6.2 & 6.3.

The depth of the water table was established by techniques outlined in Appendix 5 and it was found that the depth varied from six metres below the surface in the north of the area to 30 metres below the surface in the south.

FIG 6.1.5

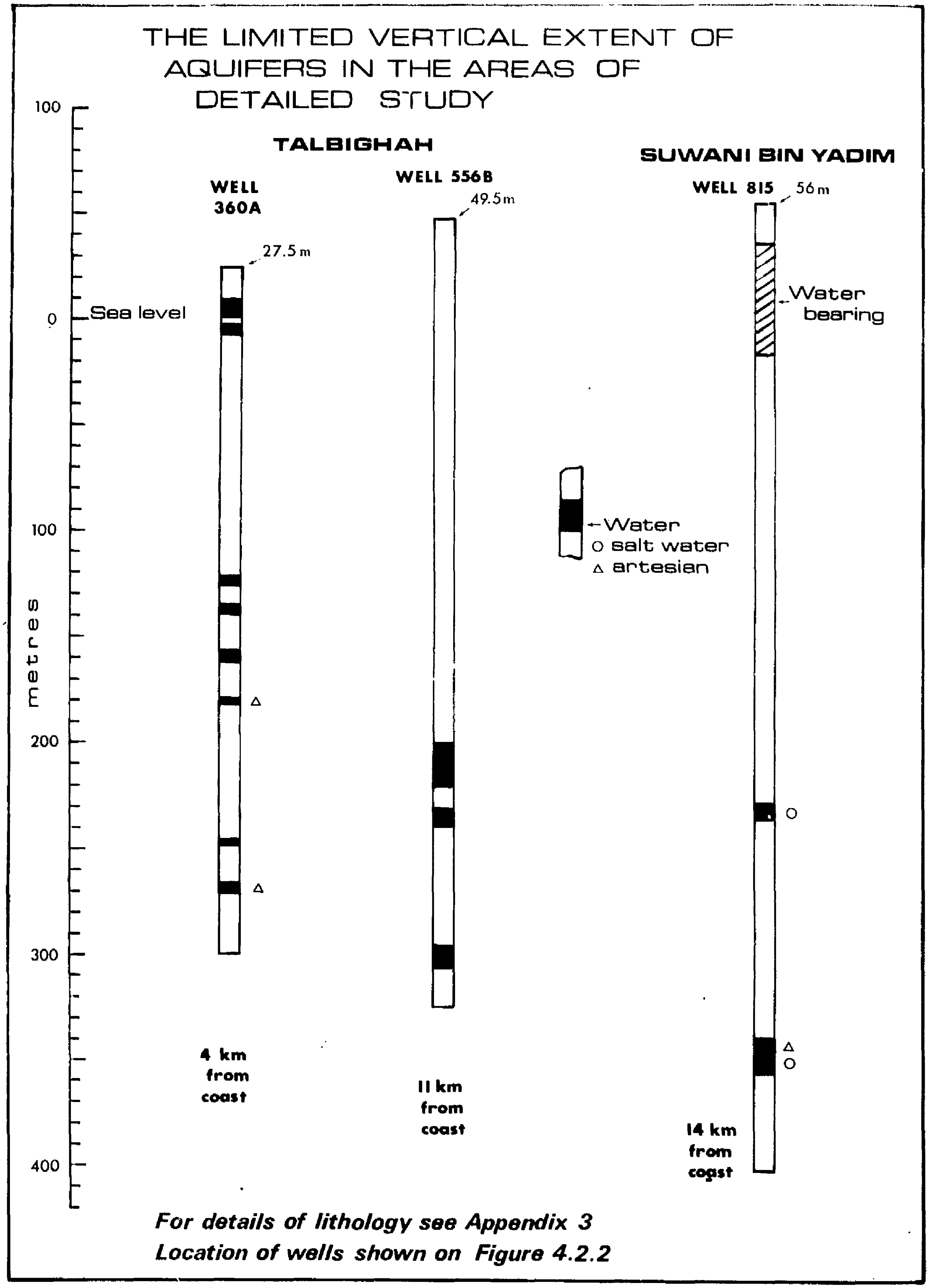
The Ghyben-Herzberg Relation



THE EQUILIBRIUM BETWEEN FRESH & SALT WATER AT THE COAST - and the salt-water intrusion danger.

After D. K. Todd

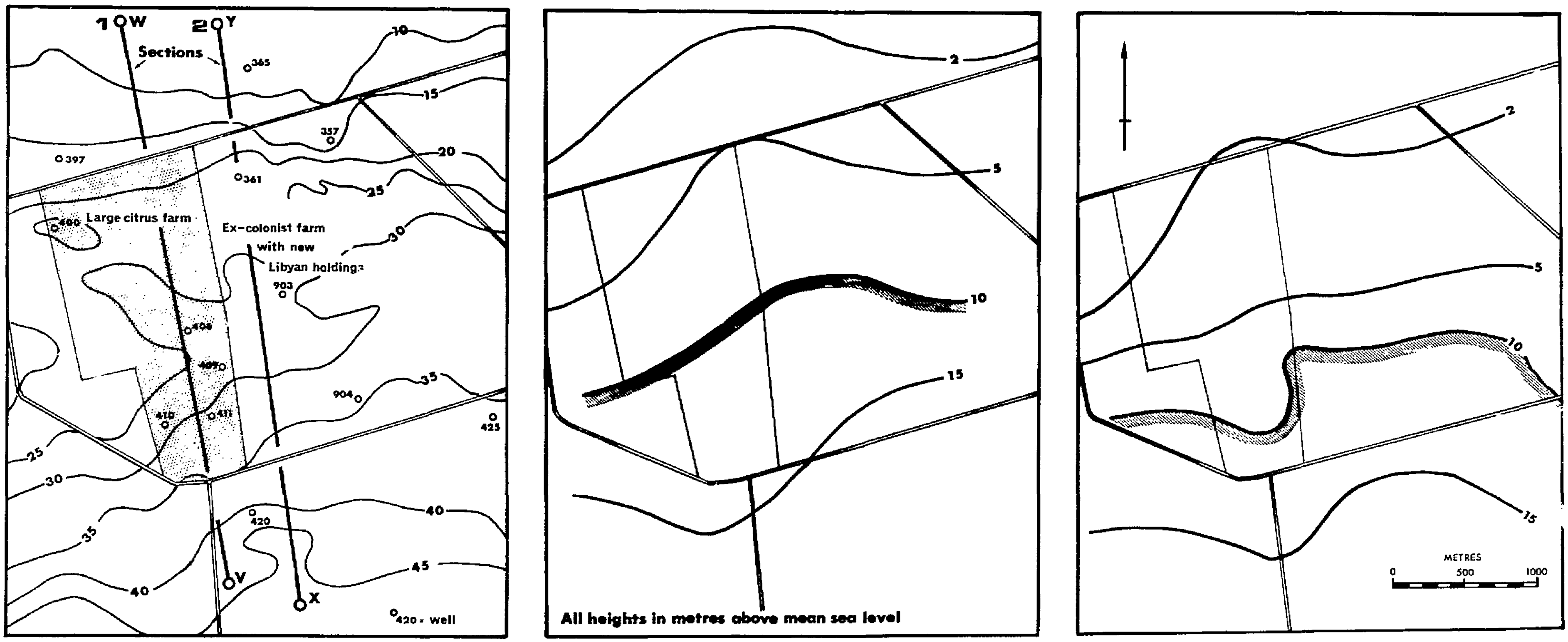
FIG 6.1.6



Source: Appendix 3

Fig 6.1.7

TALBIGHAH STUDY AREA - NORTHERN PART.



ELEVATION OF GROUND AND THE LOCATION OF THE WELLS USED TO DETERMINE UNDERGROUND WATER LEVELS

SPRING MAXIMUM 1968

LATE SUMMER MINIMUM 1968

ELEVATION OF WATER TABLE

Source: Ground levels from field 'levelling' & photogrammetric plotting. Ground water data from field measurement (see Appendix 5.1).

The figures in Table 6.1.3 show that in the north there was a very small rate of decline, while at points between five and six kilometres from the coast the decline was approximately half a metre per year.*

TABLE 6.1.3

Declining Water Levels in Talbighah in Relation to Distance from the Coast

Well No.	Distance from the coast Kilometres	Readings in winter/spring season Metres			Decline per year Metres
		1956/57	1959/60	1967/68	
1374-352-M.4	2.5	-	7.7	7.9	0.01
365	3.5	5.7	-	6.0	0.03
397	4.5	15.2	-	15.9	0.07
420	6.6	21.5	-	25.9	0.40

'-' = no readings

Sources as for Table 6.1.2

Figure 4.2.3 in Chapter 4, shows the seasonal variation in groundwater levels at a number of wells. At the Ministry of Agriculture observation well just to the north east of the Talbighah area, it can be seen that water levels have recovered each winter, over the past nine years. This well was not pumped, and so the summer drawdown reflects a complex of cones of depression resulting from heavy summer pumping in surrounding wells. The seasonal drawdown has remained unchanged since 1960, at half a metre per year, which is less than the seasonal drawdown at well 365, a kilometre further from the coast, where the drawdown was 0.8 metres each summer.

* Field records made in July 1970 and July 1971 establish that groundwater levels were declining at a rapidly increasing rate. At well no. 420 the decline was over one metre per year by 1971, and two more wells had been drilled.

An attempt has been made to assess variations in seasonal drawdown in the Talbighah area. Figure 6.1.7 shows the water levels in winter and summer, and illustrates the dangerously low levels to which water was pumped in the summer in the north, i.e. nearest the coast. Underground water was regularly drawn to below sea-level in summer; the maximum which I recorded was 3.56 metres below sea level in July 1968.

The map for the summer season indicates a higher rate of discharge in the central part of the area, the area of the large (180 hectares) modern citrus farm, which had a high water usage, estimated at over 2,400,000 cubic metres per annum in 1959/60.[8] Another large user just to the west was the group of wells which supplied the air base to the north. Cederstrom estimated the annual water usage of the base to be equal to that of one of the large farms. To the east, however, the much lower usage on the small recently acquired Libyan owned farms was demonstrated.

In two respects, therefore, the water resources of the Talbighah area were shown to be inadequate. First the excessive usage of water by the large citrus farm and the air base were causing the general decline in underground water levels from season to season. Second further withdrawal by pumps in the gardens to the north of the main road was aggravating a serious position in summer, when the level of water in the wells fell to below sea level.

6.1.4 Implications of the Decline in Underground Water Levels

(1) Exhaustion of the Aquifers

It has been shown already that the hydrology of the study area is related to a hydrological system embracing a much larger area. Precipitation falling on areas as far south as the Jabal Nafusah (80 km south) is part of the same system, and some of this rainfall finds its way into the aquifer, and then flows underground, northwards, into the study area. Unless agricultural development takes place on the Gefara Plain to the south and intercepts this flow, the existing recharge should be maintained to the coastal area and the same amount of water will continue to be supplied by this northerly flow of groundwater. Regrettably it is by no means certain that such 'interceptions' will not be introduced. Private and government farms on the Gefara seem likely to be developed, which will be to the detriment of coastal farms.

It has also been shown that although there has been no change in the rate of recharge of underground water, there has, however, been a very serious decline in underground water levels since 1911, and especially since 1963. Figure 6.1.4 shows very generalised north-south sections indicating with considerable vertical exaggeration (200 times), the scale of the decline at Suwani bin Yadim and Bin Gashir. Evidence from fieldwork and the records of the Ministry of Agriculture, as well as those of Cederstrom have been used to indicate the position at Suwani bin Yadim and at Bin Gashir, and to interpolate the likely trend at points between these places and the coast.

The hydraulic head has clearly been much reduced since 1911, but not so seriously that water ceases to flow north.

Other considerations must be taken into account. Aquifers in the Gefara are discontinuous both in vertical and horizontal extent, water being stored in sandy strata, which may in some cases be lens like in character, between almost impervious clay layers. Figure 6.1.6 shows the limited vertical extent of the aquifers in the area near the coast at Talbighah, and also in the Suwani bin Yadim area.

At Suwani bin Yadim it appears that the water bearing strata are underlain at 30 metres below sea level (which is approximately 85 metres below the surface) by impervious marl and clay. Underground water levels had already fallen to 20 metres below the surface by 1968, and were declining at one metre per year, a rate which seemed likely to increase quickly to two metres per year at the time of the study, and this prediction has been confirmed. At such a rate underground water levels will decline to below the limit of the water bearing strata in 32 years. It seems much more likely, however, that the rate of decline will accelerate even more and that the aquifer will prove to be less deep than estimated.

At Talbighah the two sections in Figure 6.1.6 show again how limited in thickness were the aquifers, and therefore how serious was any decline in the static water level. It has already been demonstrated that most of the recharge for such coastal areas as Talbighah comes from areas to the south, and it needs no further emphasis that the withdrawal of water at southerly locations such as Suwani bin Yadim and Bin Gashir, can only affect the position at the coast adversely.

To conclude, irrigated agriculture was making increasing demands on underground water resources and these have been shown to be inadequate to support the expansion and intensification at the 1968 rate. There was no evidence that long term irrigation projects would be viable, other than that based on purified sewage water.

(2) Sea Water Intrusion

Sea water intrusion has affected agriculture already at Sabratah and east of Zawiyah. At the former, government farms (N.A.S.A.) were presented from developing as planned in the early 1960s, and at the latter a citrus farm set up in the 1930s was seriously affected by 1959.[9] East of Tripoli also coastal wells were saline.*

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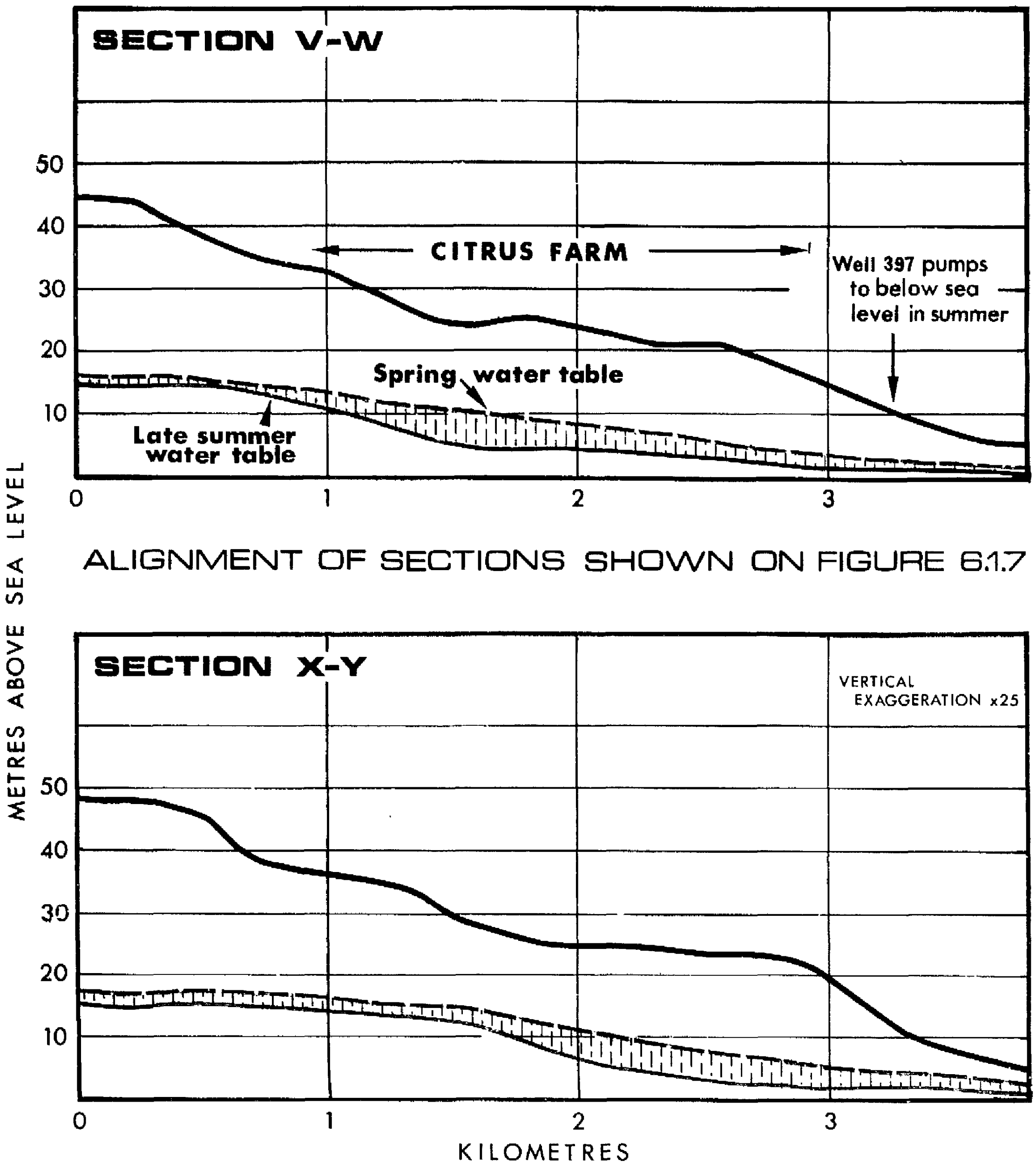
* Field visits and discussions with farmers who owned wells between one and two kilometres east of Tripoli and within half a kilometre of the sea, were affected with respect to drinking water. Underground water could still be used for agriculture, but only on salt water resistant crops such as tobacco.

The general reduction of the hydraulic gradient outlined in the previous section and illustrated in Figure 6.1.4 was partly responsible for seawater intrusions. Wells 365 and 397 within three and four kilometres of the coast respectively had static water levels in winter of 2.4 metres and 2.3 metres above sea level. In summer, however, well 365 was drawn to 1.6 metres above sea level. This well is very little used, probably on average less than one hour per day. The drawdown at the much more heavily used well number 397 was, however, greater and more serious. In July 1968 the water level was measured at 3.56 metres below sea level. The heavy requirements of the farm and the nearby tomato factory, also supplied by the well, were clearly causing a large cone of depression, and although at four kilometres from the coast it could not be argued that this was contributing to salt water intrusion in the immediate area of the well, it does indicate the serious position which could occur at heavily used coastal wells, especially those 'coastwards' of such areas of heavy undergroud water usage as Talbighah.

To illustrate the effect of heavy summer usage of ground-water in the Talbighah area Figure 6.1.8 has been drawn. Both sections show clearly the depression of the water table in summer, and the relationship of the area of greatest decline with that of heaviest pumping. The shortage of summer water at Well 397 south of the citrus farm is partly explained by the citrus farm's heavy usage.

It is important to note that despite the recovery of water levels in winter there was still a serious annual decline as indicated by the comparison of pre World War II levels with 1956-1960 records which are shown in Appendix 5.1. At well 420 for example, levels fell from 16.40 metres in 1939 to 22.10 metres in 1960.

TALBIGHAH STUDY AREA FIG 6.1.8



SECTIONS SHOWING THE EFFECT OF THE HIGH SUMMER USAGE OF WATER BY THE CITRUS FARM

The effect of all this high summer usage was to further aggravate the already weakening balance between salt and fresh water at the interface further north beneath the coast.

(3) The Increased Cost of Irrigation Water

The constant and increasing decline in underground water levels will inevitably bring about an increase in the cost of irrigation water, first through the cost of deepening wells and next as a result of higher pumping costs; these are long term problems.

As far as the farmer was concerned with subsidies on electric power (pumps were usually powered by electricity) and with personal and government funds available for investment the difficulties were not serious. In real terms, however, the position was already serious. It is unlikely that the cost of new wells in the Suwani bin Yadim area will be recovered. At 1968 prices the cost of irrigating a hectare of citrus for a year was about £L 47, without including labour, maintenance and depreciation (assuming 1.10 cents(US)/m^3 for fuel costs in raising and distributing water, and the use of 12,000 m^3 per year). The total annual cost per hectare for another Mediterranean location,[9] using spray irrigation was found to be 3.4US cents/m^3, giving an annual cost per hectare for a 12,000 m^3 usage per year of £L 146.

Turnover from the most efficient commercial enterprise was in the region of £L 600[10] per hectare in 1968. Against this the above expenses of water distribution must be set, as well as other farm expenses, and the cost of marketing and of the original seed. It is unlikely that turnover exceeded £L 400 per hectare on the very best Libyan farm in the study area. In addition it was unusual for farmers to raise cash crops on more than one hectare intensively. It is very unlikely therefore, that the costs of building wells at £L 1000 each and of purchasing pump and spray equipment for a further £L 1000 could be financed from farm income, on such farms.

Total farm income could not be accurately assessed, nor the precise importance of 'off-farm' income. It is therefore on the basis of field enquiries that it is concluded here that even from a well managed hectare of farm-land, turning over say £L 400 per year, and costing £L 146 to irrigate, it was not possible to derive economic returns from agriculture in 1968. Only a few of the additional costs could be estimated. Harvesting labour costs, for example, might amount to between £L 39 and £L 59 per hectare, depending upon the irrigated crop.[11] Land preparation, planting and cultivation might account for another £L 50 per hectare for irrigated crops.[12] With other costs running at over £L 100 per year, i.e. seed, transportation, distribution, fuel, repairs, even well managed farms were running at a level which would afford a mean standard of living for a family. It would certainly not allow farm investment and other expenditure which has been shown to have been in progress elsewhere in this study for the 1967/68 period.

The continued extension of irrigated farming and related stock rearing arose only because there were subsidies and 'off-farm' income to finance the well construction and equipment purchase for irrigated farming, together with feed subsidies (50%) for the farmer engaged in stock rearing.

It is inconceivable that the higher water costs which will result from higher running expenses* as water must be lifted from greater depths, and additional charges incurred through well deepening, could be recovered from the sale of produce. This is especially so as other costs were rising also (see next section 6.2) and local labour was unreliable. All evidence points to there being no 'real' profit in

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* The subsidy to the farmer for electric power used on the farm will continue to obscure the real economic impact of falling water levels as most pumps were electric.

Libyan irrigated farming; only a subsidised profit to the farmer. In this situation the continuously falling water table, which will bring further increased costs, was one of the most important factors 'acting against an extension of truly profitable irrigated farming in the study area.

6.2. The Increasing Cost of Agricultural Labour

6.2.1 Introduction

It has been becoming clear that there are a number of factors increasing the costs of farming, and in concluding the preceding section, which concerned rising costs arising from the disadvantageous arrangement of underground water resources in the study area, some measure of the importance of agricultural labour costs as an element in the farm budget was introduced.

Labour costs differ from those related to water raising and distribution, however, in that there is no easy way to subsidise expenditure on farm labour. We have seen that irrigation is subsidised through cheap electric power, and through subsidies and credit advanced to instal the necessary equipment.

To subsidise wage labour on Libyan farms before 1968 would have required a system for the distribution of supplementary wage benefits far beyond the administrative capacity of the government of the time. Such administrative services were already extended.

In the event, by 1968 the agricultural sector had become something of a 'wage-leader' with respect to both permanent and temporary labour,[13] and such developments brought about the difficulties to be outlined in this section.

Labour was a very important input in any Libyan farm enterprise. It constituted between 20% and 40% of the total costs of agricultural production, depending upon the crop involved. It will be shown that increases in agricultural wages in the order of six times 1952 levels were normal by 1968, while the prices of agricultural products had risen only two and sometimes threefold in the same period. Some of this pressure had been absorbed by government subsidies and loans to farmers, as well as by off-farm income, but those farmers still engaging in agriculture in 1968 with an economic return in mind were experiencing more and more difficulty. Some were aware that their farms were not economically viable in 1968,* and could only be regarded as such in the long run if levels of wages remained steady and prices to the farmer buoyant.[14] It will be shown that government intervention alone could bring such conditions about, not directly by fixing wages or prices but by reorganising the supply of labour by permitting foreign labour (Tunisian or Egyptian) to enter the country and secondly by protecting the Libyan product from foreign competition.

This section on wages will not be treated in a geographical sense in that no important regional variations in wage levels were determined from the study of either the Western Provinces[15] or the study area with which this thesis is concerned. Nevertheless the importance of wages as a general economic indicator, as well as an indicator of developments in the study area make it necessary to examine the relevant background to wages structures in the recent past, to quantify where possible average wage levels in the various sectors of the economy and to observe their interaction. Finally trends in wage levels will be established in order to provide evidence for the

* Farmers were aware that any profit in certain enterprises, e.g. chicken rearing and certain other stock rearing, was dependent on the government feed subsidy.

purpose of this thesis, confirming that the rising price of labour was a second factor* inimical to the development of a viable agriculture in the study area.

The organisation of the discussion will be to treat first the situation before oil, and secondly to assess the impact of oil on the price of agricultural labour. The latter will be examined by stages, looking first at the period of exploration, then at the 'pre-exportation phase', and finally at the 'oil revenues phase'. On the basis of the evidence presented in this discussion likely future developments in the structure of agricultural wages will be anticipated and the effect of these upon Libyan farmers and agriculture in general will be assessed.

6.2.2 The Impact of Oil on the Price of Agricultural Labour

It is to be expected that the commencement of oil operations in a poor country will bring attendant economic pressures, which will partly be manifested in rising wage rates. Such increases, however, can only be attributed to a very minor extent to the demand for labour by the petroleum sector. In addition the petroleum sector could not be regarded as the one in which the highest wage rates always obtained, as by 1968 this sector was not the 'wage-leader' in Libya, unlike other petroleum rich countries in the developing world.[16]

The insignificance of the numerical pressure of the demand for labour of the petroleum sector on the employment market can be seen in the results of the 1964 national census, where it was shown that the whole industry employed 9660 persons (out of 11575 in mining and quarrying), compared with 140,517 in agriculture, forestry and fishing, and with 367,834 which was the total of the economically active male

* The first was the rising cost of irrigation water as outlined in section 6.1.

population.[17,18] Thus those employed in the oil industry amounted to less than one per cent of the total labour force, and even when other ancillary labour such as that engaged in transportation and construction is taken into account, still less than two per cent of the total labour force was directly or indirectly remunerated by the oil companies.[19]

Before 1964 there had been periods, especially during the height of the exploration phase when more labour was employed by the petroleum sector and associated activities, but not so that numbers ever closely approached two per cent of the total labour force. The table below shows the numbers employed in the petroleum industry between 1961 and 1964, which was a period of vigorous exploration reflected in the slight increase

TABLE 6.2.1

Libyan Nationals Employed in the Petroleum Industry During 1961 - 1964

Year	No of Persons
1961	7950
1962	8150
1963	9000
1964	9500

Source: Census and Statistical Department, Ministry of Economy and Trade, Statistical Abstract 1965, Tripoli 1964. p. 91.

in the personnel employed. Figures for the period 1964-1968 are not available in the same form, but data relating to 'oil concession firms' have been quoted by Mabro.[20]

TABLE 6.2.2

Workers in Oil Concession Firms

Year	No of Persons
1964	5510
1965	5872
1966	5669
1967	5378
1968	5739

Source: Mabro, R.E., 'Labour Supplies and Labour Stability, A Case Study of the Oil Industry in Libya in Bulletin of the Oxford University Institute of Economics and Statistics, Vol 32, No 4, 1970. p. 321

He points out that the shift from exploration to production, which took place in the 1964-1967 period, was labour saving in character, and so Table 6.2.2 shows a predictable stability in terms of the total numbers employed.

In terms of numbers, therefore, the petroleum sector has not exerted significant pressure on the labour market. Concerning the second feature, that of wage rates it has already been mentioned that by 1968 agricultural wages were on average in excess of those for equivalent employment in the oil industry.

TABLE 6.2.3

Average Wages in the Main Sectors - 1968

	£L per Day
Agriculture	1.00
Oil	0.75
Government	0.70 - 0.80
Construction	1.20

Source: Mabro, R.E., 'Employment and Wages' in Penrose, E.T., Allan, J.A. & McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970. p. 159

This had not always been the case, however, as shown by data obtained by the author from farm accounts for a large farm near Tripoli, which have been compared with oil company data contributed by certain oil companies.[21] Agricultural rates were only £L 0.145 per working day in 1956, while oil companies were paying between £L 0.250 and £L 0.400 for equivalent unskilled labour. This reversal of positions which, it has been observed, came about by 1968 had arisen through the interaction of a number of variables, not least the changes in the labour market and in the expectations of the Libyan working population, following the implementation of generous government employment policies, especially in the early 1960s.

To look next in a little more detail at the background to the wages position in Libya in 1968 where it has relevance to further developments in employment and wages in Libya.

(1) <u>The Exploration Phase 1956-1959</u>

The conditions which prevailed with respect to employment and wages during the period of oil exploration cannot recur in Libya, at least during the life of the present proven reserves which seems assured at current rates of extraction for at least fifty years. Even if exploration were to be taken up with renewed vigour, it is unlikely that more than an additional 5000 people would be involved.

During the first phase of involvement with the oil companies Libya conformed to the general model found applicable in so many parts of the developing world. Wage levels in agriculture were lower than those in the 'modern sector', i.e. in the urban areas; the differential was small, but in the right direction with reference to the model. Oil companies offered very much higher wages than existed in agriculture or industry, especially for labour undertaken in the desert. But the most important changes which took place in this period occurred in the towns to which many migrants from the rural unemployed and underemployed had been attracted through an awareness of the wage-differentials and other expectations.

Neither local industry, nor the oil companies' undertakings in Tripoli and Benghazi nor the service sector (that section of the economy most stimulated by the exploration for and development of oil), could absorb the rural migrants, and a very difficult situation began to develop.

(2) Pre- and Early Exportation Phase 1960-1962

This situation became progressively more difficult as the discovery of oil was announced in 1959 and the first exports were completed in 1961. Possibly predictably, the government attempted to resolve the problem by implementing policies with respect to employment and wages which have had repercussions in all sectors of the economy (although probably least in oil), and have set a pattern of employment which has already shown itself to be resilient in the subsequent period of economic change and development, and even through the political upheavals following the September 1969 revolution.*

(3) Oil Revenues Phase 1963-1968

When oil revenues began to become available (see Table 6.2.4), the government was forced to take action in order to appear to satisfy the expectations of the population. At the same time a number of additional problems had to be taken into account. We have already mentioned the urban unemployed who were becoming dangerously numerous by the early 1960s. A second and directly related problem was that of migration from the agricultural sector, which as we saw in sections

* One of the first acts of the new regime was to follow precedent and exert legislative pressure on wage levels by setting a minimum wage rate about twice as high as the previously legislated figure.

TABLE 6.2.4

Exports and Value of Exports of Petroleum

1961 - 1968

Years	Exports in U.S. Barrels '000	Value of Exports £ Libyan '000*
1961	5,246	4,097
1962	65,453	46,984
1963	167,531	116,861
1964	313,878	216,400
1965	442,388	280,331
1966	547,528	351,441
1967	627,882	416,426
1968	944,426	667,262

* These figures do not represent government revenues; they do indicate the rate of increase of production since 1961.

Source: Census and Statistical Department, Ministry of Planning, Statistical Abstract, 1968, Tripoli 1969. p. 140.

5.1.2 and 5.1.3 was a sector of the economy which was far from vigorous. Agriculture had been allowed to run down, and many farms were relatively unproductive in the 1950s and in the years before oil revenues became available to the government. The latter was, therefore, faced with the problems of maintaining the rural population on the farms and at the same time stimulating the productivity of agriculture in Libya.

The government responded by creating new jobs in its own ministries, departments and security services. Salary scales were revised, and further raised in 1964 and 1966. In addition family and housing allowances were introduced. Such employment and allowances were made available to people who lived in all the dispersed municipalities and villages, as well as to farmers and their relatives, and so the rural as well as the urban population was affected. In this way the pressing problems of urban unemployment, rural depopulation and declining agricultural productivity were at once seen to have been treated in a politically appropriate manner.

That the rural population was affected was confirmed by both the 1967 and 1968 surveys of the Joint Project. The latter showed that of the 28% of farmers sampled who undertook 'off-farm' employment, 47% of these worked for the government.[24] Other government work was available to relatives, for instance, of eldest sons with 'off-farm' employment 16% worked for the government.[25] Data for 1967 for two areas in Western Libya show how government revenues were being distributed widely in the study area of the western part of the country.

TABLE 6.2.5

'Off-farm' Employment of the Farmer in

Areas of Western Libya 1967

Area*	No of cases in study	No of farmers with 'off-farm' employment	Per Cent in Government Employment of Those with Jobs 'Off-Farm'	
			Full-time	Part-time
Tripoli	287	151 (52.6%)	51.0%	11.9%
Jabal Gharbi	300	97 (32.3%)	46.4%	29.9%

* These areas were case study areas in which all farms were enumerated, as far as possible. There were 7 case study areas in the Tripoli area dnd 4 in Jabal Gharbi

Source: LULUJRP, unpublished data in computer tabulated form resulting from the July 1967 field survey.

The 1967 data indicate that an even higher proportion of farmers were engaged in 'off-farm' employment, with 52.6% of farmers having jobs in addition to work on the farm in the Tripoli area, with almost 63% of these employed by the government. In Jabal Gharbi the proportion with jobs off the farm was somewhat less, but a very similar proportion of the total population was benefitting directly from government employment. In the Tripoli study areas 33% of the total farming population had government jobs, compared with just under 25% on the Jabal Gharbi. The policy was therefore successful in terms of making work available in all rural areas.

The government policies of directing oil revenues to 'trickle-down' to the farming community was clearly successful, at least in terms of the numbers affected. Further confirmation of the wide-spread character of 'off-farm' employment is very clearly illustrated in Figure 6.2.1

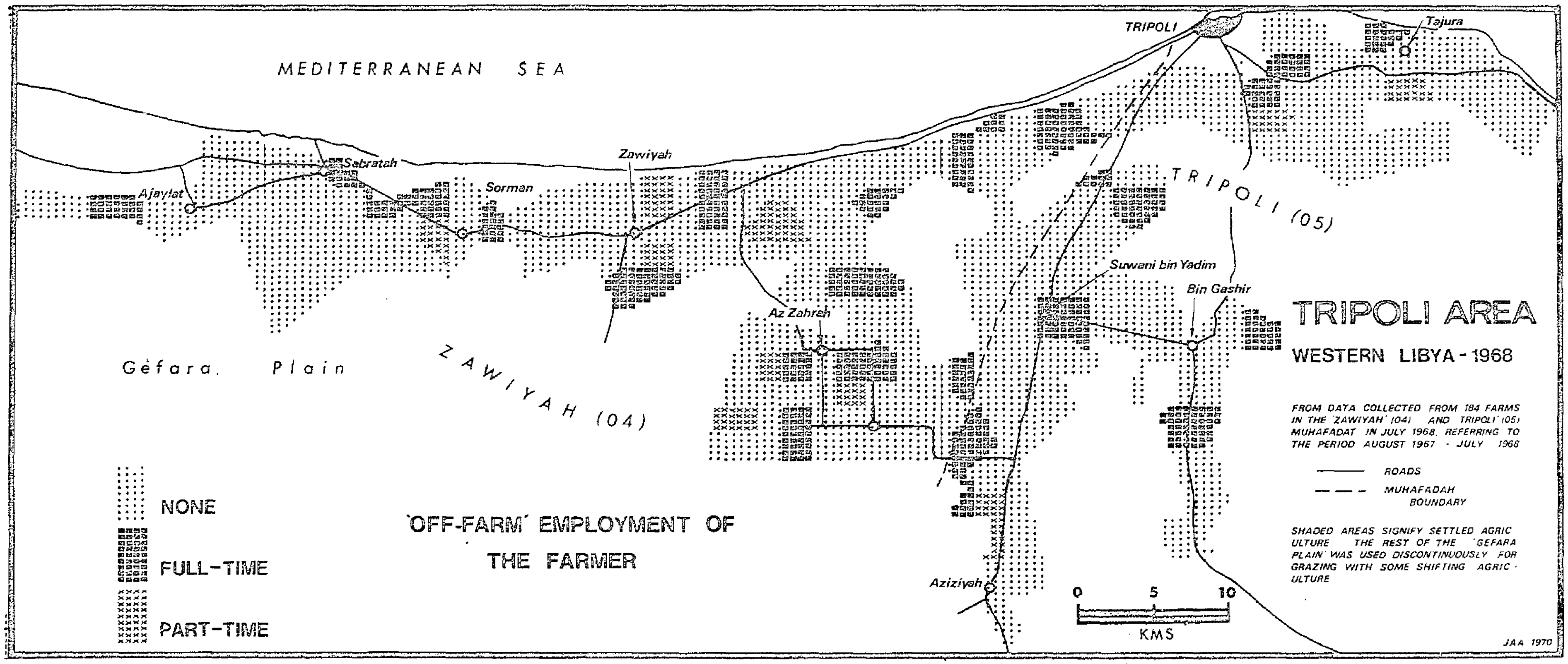
TRIPOLI AREA
WESTERN LIBYA - 1968
'OFF-FARM' EMPLOYMENT OF THE FARMER
FROM DATA COLLECTED FROM 184 FARMS IN THE 'ZAWIYAH' (04) AND TRIPOLI' (05) MUHAFADAT IN JULY 1968, REFERRING TO THE PERIOD AUGUST 1967 - JULY 1968
ROADS
MUHAFADAH BOUNDARY
SHADED AREAS SIGNIFY SETTLED AGRICULTURE THE REST OF THE 'GEFARA PLAIN' WAS USED DISCONTINUOUSLY FOR GRAZING WITH SOME SHIFTING AGRICULTURE
NONE
FULL-TIME
PART-TIME
MEDITERRANEAN SEA
Gefara Plain
ZAWIYAH (04)
TRIPOLI (05)
TRIPOLI
Tajura
Ajaylat
Sabratah
Sorman
Zawiyah
Az Zahrah
Suwani bin Yadim
Bin Gashir
Aziziyah
0 5 10
KMS
JAA 1970

FIG 6.2.1

In this discussion of agricultural wages, however, the wage rates fixed by the government for government employees together with their considerable additional benefits (for example with respect to family and housing allowances), were of even greater significance. Field enquiry of farmers and their families indicated that government employment appeared to carry with it some assurance of security as well as favourable remuneration. These attitudes were found throughout all of agricultural Libya as examined by the Joint Project surveys, and it was not surprising, therefore, that agricultural wages had to be competitive with those available in government employment, where terms of employment were considered to be the most generous.[27]

Table 6.2.3 showed that by 1968 agricultural wages at £L 1.00 per day were higher than in other sectors except construction, where the arduous and unreliable nature of such work was reflected in the average rate of £L 1.20 per day. It should also be noted that the £L 0.75 - £L 1.00 quoted for government employment reflected the permanent character of this type of employment together with the allowances and benefits outlined elsewhere.

In order to examine the wages paid in 1968 in agriculture in a little more detail, further data collected by the Joint Project is set out in Table 6.2.6 These show that there was little difference between rates for permanent and temporary workers, although some

TABLE 6.2.6

Male Workers

Agricultural Wages in Western Libya - 1968

£ Libyan per day

	Temporary Workers		Permanent Workers	
	Lowest rate	Highest rate	Lowest rate	Highest rate
Range	0.40 - 1.50	0.5 - 2.00	0.40 - 1.50	0.60 - 1.80
Mode	1.00	1.00	1.00	1.00
Median	0.80	1.00	0.80	1.00
Mean	0.82	1.12	0.82	0.90

Source: LULUJRP data - field survey of 371 farms in Western Libya.

temporary workers did have an opportunity to earn at higher levels, (which is to be expected in temporary employments where idle periods have to be taken into account) as shown by the higher mean figure of the highest rate for such workers in Table 6.2.6.

In 1968 the average rate for both temporary and permanent workers was £L 1.00 per day, and the minimum wage at which a farmer could hire labour was very similar for both permanent and temporary contracts. The higher maximum for temporary workers possibly reflected a shortage of seasonal labour with the consequent payment of a premium for such requirements during, for example, harvesting peaks.

It is important to draw attention to an important stratification in the structure of wage labour in Western Libya which has relevance to this discussion of maximum and minimum rates. This 'stratification' has already been noted in the analysis of changes in agriculture with respect to the intensification of irrigated farming in the study area in section 5.2.2, where it was found that Tunisian farm labourers provided an essential element in the running of many farms. By 1968 a farmer[28] with seven labourers found it desirable to recruit five of these from Tunisia.* Farmers found Tunisian labour to be well motivated. The normal rate of £L 1.00 per day was more than acceptable to them. Often, however, a lower rate of between £L 0.70 and £L 0.80 was paid to Tunisian workers. This was still above the legal minimum of £L 0.50 which obtained in 1968.** The employer was in a strong position in fixing a lower rate for Tunisian labourers as in many cases they were uneasy about their legal status and on occasion

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* By 1971 this same farmer[29] was employing 11 labourers of which eight were from Tunisia.

** In 1971 the minimum rates did not appear to have moved significantly higher despite the legislation following September 1969 which instituted a minimum legal wage of £L 1.00 per day. Lower rates again reflect payments to Tunisian labour.

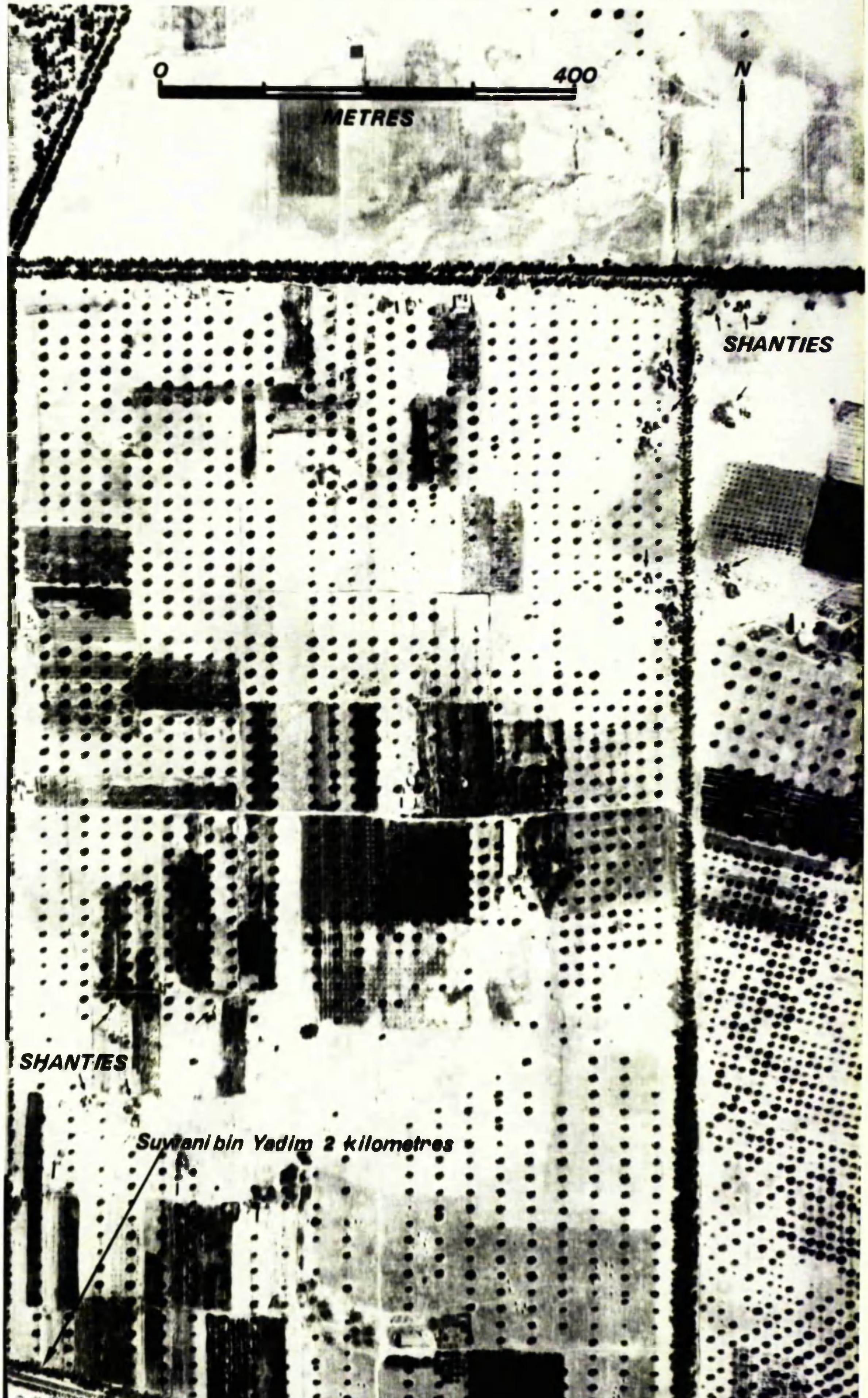
were in fact illegal immigrants. They lived in poor accommodation, including shanty-type dwellings, sometimes with their families, in the least obvious and least accessible parts of the farms.(See Fig. 6.2.2)

The presence of the Tunisian element in the agricultural labour force is symptomatic of another unsatisfactory feature of Libyan agricultural wage labour. This was its instability in terms of turnover. There were no data on this feature, but it was a matter about which many farmers complained. They were uneasy about the attitude of their Libyan farm labourers and especially concerning their propensity to leave. Other types of employment always seemed more desirable to the farm labourer, and with respect to conditions of work all other jobs other than construction, were known to be less demanding than agricultural work. Such attitudes clearly contributed to the pressures forcing agricultural wage rates to rise.

It was an accident that the agricultural sector was the least regulated sector in terms of official government or revenue department supervision of wage payments. This was important with respect to the employment of Tunisian labour, in that this was the only sector in which Tunisians could obtain unofficial or illegal employment. They could not be employed at unskilled levels by the government, and in construction, other than on the farms; their presence if illegal would be noted as payments to them through an official payroll were impossible. Only in the relatively remote situation of the farms could the illegal employment practices go unnoticed.

At the same time the government were permitting the entry of some Tunisians for agricultural work, and were to a limited extent responding to the pressure from Libyan farmers and from Tunisian workers wanting employment, by granting entry permits for prescribed and generally short (up to one year) periods.

'SHANTY' DWELLINGS ON LARGE FARMS IN THE SUWANI BIN YADIM AREA FIG 6.22



Thus the supply of labour to the agricultural sector was subject to a number of outside factors. First, the supply of Libyan labour was being depleted through the preference of unskilled labourers for the greater security and better, and less demanding, working conditions of the government and the oil companies. Secondly, the supply was being increased by the introduction of unskilled labour from outside the country.* One of the most important features of this labour from outside was that it was obtainable at wage levels much below normal rates, and therefore not only did its presence tend to reduce the pressure on wage rates through improving the supply of agricultural labour, at the same time it did not exert pressure at the top end of the unskilled agricultural wage rates, as minimum rates were acceptable to this foreign labour.

Despite the possible stabilising effect of labour from outside Libya on agricultural wage rates, the evidence available is that such rates increased steadily during the 1963-1968 period. No official data are available for this period and therefore average rates derived from a large farm near Tripoli have been quoted. These rates were derived from comprehensive accounts made available to the author.[31]

TABLE 6.2.7

Agricultural Wages on a Large Farm Near Tripoli, 1963-1968

Year	Median Daily Wage £L	Index
1963	0.30	100
1964	0.40	133
1965	0.50	166
1966	0.60	200
1967	0.65	217
1968	0.80	266

Source: Wages data from a large farm near Tripoli made available to the author.

* Tunisian labour was frequently not 'unskilled' in the agricultural sense. Libyan farmers often sought such workers because of their special knowledge of irrigation methods or winter dry farming techniques. There was evidence of Tunisian workers coming in on tourist visas to set up such schemes as early tomatoes.[30]

It is clear from Table 6.2.7 that agricultural wage rates responded to the important employment and wages policies introduced by the government, which affected first the supply of labour, through the expansion of employment in the government sector, and secondly the price of labour through the upwards adjustment of wage rates in 1964 and 1966 for government employees. In this 'oil-revenues phase' the price of agricultural labour rose almost threefold on this farm, where it should be noted that an unusual stability of employment and low labour turnover had been maintained through skilful management. Further evidence of the quality of the management is that in addition to the low rate of turnover, the average wage levels were somewhat below the levels obtaining elsewhere. We have seen that average rates were running at £L 1.00 per day, whereas equivalent labour was being paid £L 0.80 per day on this farm. This situation reflects the relative permanence and security of employment, as well as some other fringe benefits available on the farm, for example accommodation, and the right to cultivate small plots.

The important message in Table 6.2.7 is, however, the trend in wage rates in the agricultural sector. The implications of the continuance of such trends will be examined next, against the background of the supply conditions likely to obtain in the labour market for agriculture.

6.2.3 Implications of the Increase in the Price of Agricultural Labour

Libyan agriculture was becoming more intensive throughout the 'oil revenues phase', in terms of the level of input, whether measured as capital, labour, or fertiliser inputs, etc (see Sections 5.1.2 and 5.1.3) or in terms of the proportion of farms cultivated especially with respect to new irrigated areas. The higher levels of labour input were mainly met by the farmer and his family, but an important element was that supplied by wage labour. Such developments seemed likely to continue despite the two major factors acting against the long term profitability of irrigated farming in the study area. The first of these, namely the rising cost of water has been established in section 6.2.1 It remains to show that the rising cost of Libyan wage labour would in the long run be an important constraint on labour intensive farming', i.e. irrigated agriculture, the most rapidly expanding section of farming in the study area.

Wage rates were likely to continue to rise because of factors external to agriculture. Because the government in the early 1960s increased its establishment in ministries and security services, in order to distribute the oil revenues, it was, and will continue to be, committed to maintaining the expectations of this disproportionately large section of the wage earning community. It seems very likely therefore that the government sector will continue to be the 'wage leader'.* Unlike agriculture, however, the government sector has no measure of its efficiency and profitability. The high wage levels which resulted from this method of distributing oil revenues have, however, disturbed very considerably the balance between costs and returns in irrigated farming, especially as prices have not risen at an equivalent rate. Price indices for the food group in the Tripoli market[32] moved from 140 in July 193 to 189 in July 1968 (1955 = 100), reflecting a 26% increase in prices in a period when we have seen that agricultural wage rates rose 266% (see Table 6.2.7 and Appendix 12).

Unfortunately the government was, and will continue to be faced with an impossible dilemma concerning the development of agriculture. Policies, including those to control prices, have been designed to prevent price inflation. Such policies clearly act against

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* The government sector was certainly the wage leader if allowances and 'fringe benefits' were taken into account.

the farmer who requires higher prices for his produce to cover rising labour costs. At the same time the farmer needs protection from foreign competition, for even those products which he can produce at a reasonable quality, such as fruit, are often disadvantageously placed in comparison with imported produce. Such a position can only be aggravated by a continuation of the trend in wages indicated in Table 6.2.6

The government was already subsidising agriculture in a number of ways in 1968, directly through loans and with equipment and feed subsidies, and indirectly by providing 'off-farm' employment. If the prices of agricultural products are to be kept down, it will be necessary, in additional ways, to subsidise such prices to the consumer to offset the rising cost of labour, and also to protect the Libyan agricultural products from foreign competition. An alternative and equally difficult policy, which could allow agricultural wages to be kept down, would be to allow foreign labour from other Arab countries to enter the country to work on the farms, in considerably larger numbers than hitherto.

6.3 The Results of Government Support to Agriculture

In this section the statement that 'government support in the form of loans and subsidies were important to maintain agricultural development' will be examined further. Much attention has already been given to the special position of the government with respect to agricultural development. We have looked at the broad impact of oil revenues on the national economy in Chapter 2 where the role of government was outlined. More detailed aspects of the government's significance have been encountered in the preceding sections of this chapter (6.2 and 6.1) where government sponsored agricultural credit and government wages policies have been shown to have brought problems with respect to the costs of water and of unskilled agricultural labour. In concluding section 6.2. of this chapter it was also made clear that the national government alone could influence the economy generally, and the labour market in particular, to the advantage of the agricultural sector.

The special position of the government in the economy of Libya contrasts markedly with the situation in most developing or more developed non-communist economies. An oil rich national administration is faced with the problems of development without the support of a private sector with a mutual interest in capital formation. The private sector in the 'phase of oil revenues' (1962-1968) did expand considerably, but Table 6.3.1 indicates that this expansion took place in the tertiary

TABLE 6.3.1

Gross Domestic Product at Constant (1964) Prices 1962 to 1968

Source	1962	1963	1964	1965	1966	1967	1968
	Million Libyan Pounds						
1 Agriculture	17.4	17.3	16.5	23.1	21.0	22.9	21.7
2 Mining and Quarrying							
Petroleum mining	51.5	115.9	197.5	256.3	306.1	340.8	514.4
Other mining & quarrying	0.7	0.7	0.8	0.9	0.9	1.0	1.1
3 Manufacturing	10.0	10.5	11.5	12.3	13.9	15.8	18.9
4 Construction & Public utilities							
Construction	13.2	14.6	23.0	34.9	38.7	50.9	62.7
Electricity and gas	0.9	1.1	1.3	1.5	1.9	2.2	2.9
5 Transport, communications	10.0	12.1	14.3	16.8	20.6	24.6	29.8
6 Commerce							
Wholesale and retail trade	15.9	19.4	28.2	31.9	38.7	43.1	53.1
Banking and insurance	2.0	3.1	5.2	6.6	7.7	8.7	10.1
7 Services							
Public Administration and Defence	16.6	19.9	25.3	33.4	39.1	46.0	56.3
Educational services	5.6	7.5	9.6	12.3	14.7	17.2	21.4
Health services	2.3	2.8	3.4	4.2	5.6	6.5	8.7
Ownership of dwellings	30.7	31.5	33.4	35.2	37.6	38.3	40.3
Other services	5.9	6.4	7.1	8.0	8.7	9.0	9.4
GDP at factor cost	182.7	262.8	377.1	477.4	556.2	627.0	850.8
Net income sent abroad	7.0	9.8	77.3	78.2	96.2	124.9	214.7
Depreciation	16.7	22.8	28.6	34.6	38.3	47.4	50.4
National Income	159.0	230.2	271.2	364.6	421.7	454.7	585.7

Source: Census and Statistics Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli, undated, pp. 52-53.

Note: Table showing GDP at current prices can be found in Appendix 8 activities of commerce (including wholesale and retail trade, banking and insurance) and services (including administration, education, health services, ownership of dwellings etc.), rather than in agriculture and manufacturing. Construction was vigorous in the period but much of this development was concerned with improving the poor housing stock of the country, and could not be regarded as capital forming. Tables 6.3.2 and 6.3.3 present comparative figures for 1962 and 1968 to illustrate the relative expansion of the various sectors of the economy.

TABLE 6.3.2

GDP at Current and Constant Prices by Source 1962 and 1968

	Current Prices		Constant (1964) Prices	
	Million Libyan Pounds			
Source	1962	1968	1962	1968
Agriculture	15.0	33.0	17.4	21.7
Mining	35.2	656.7	52.2	515.5
Manufacturing*	9.9	23.0	10.9	21.8
Construction	10.9	91.1	13.2	62.7
Communications	8.2	37.6	10.0	29.8
Commerce**	16.4	75.6	17.9	63.2
Services	56.9	178.3	61.1	136.1
Total at factor cost	152.5	1,095.3	182.7	850.8

* including electricity and gas
**including banking and finance

TABLE 6.3.3

Per Cent Increase in GDP - 1962 to 1968

	At Current Prices	At Constant Prices
	1968/62 %	1968/62 %
Agriculture	220	125
Mining	1,866	988
Manufacturing	232	200
Construction	836	475
Communications	459	298
Commerce	461	353
Services	313	221
Total	718	468

Source: Census and Statistical Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli undated. pp. 53-54.

It has been shown in chapter 5 in sections 5.1 and 5.2 that significant changes have taken place in agricultural land use and output, and by way of confirmation Table 6.3.3 indicates that those responsible for national planning in 1968/69 estimated that the agricultural sector was expanding at the rate of almost four per cent per year at constant prices. This estimate was probably high, but no reliable research has been completed to provide more accurate data. Certainly the Libyan market had proved itself well able to cope with such increases in supply in that food imports had been shown to be increasing at a very much higher figure than domestic output, at 15% or more per year up to 1968. (See Figures 2.3.2 and 2.3.3)

6.3.1 Government Allocations and Loans to the Agricultural Sector

The extent to which the government contributed directly to the development of agriculture is shown in Table 6.3.4 and Table 6.3.5, with respect to the 'development' and 'ordinary' budgets during 1963-1968, the 'oil revenues phase,' as well as the period covered by the first 'five year plan'.

TABLE 6.3.4

Government Dependiture on the Five Year Plan 1963-1968
(Development Budget)

Head	Financial Year					
	1963/64	1964/65	1965/66	1966/67	1967/68	Total 1963/68
Agriculture	1,336	1,885	7,112	10,044	17,373	37,750
Industry	43	606	2,005	4,682	7,370	14,706
Economy and Culture	160	526	534	622	1,006	2,848
Communications	4,409	6,349	13,082	9,301	19,607	52,748
Works	5,757	10,360	14,955	16,874	39,386	87,331
Education	524	1,079	5,570	9,115	9,638	25,926
Health	118	233	772	2,053	5,487	8,663
Labour etc.*	43	1,629	3,519	3,346	5,251	13,788
Interior	-	-	2,909	9,485	7,414	19,808
Housing	-	-	-	11,558	17,917	29,475
Planning x	144	236	1,485	4,747+	-3,240+	3,374
Other	9	88	414	424	893	1,828
Total	12,543	22,991	52,357	82,252	128,102	298,245

* Labour and Social Welfare
x Planning and Development
\+ Book adjustments

Source: Census and Statistical Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli, undated, p.124.

TABLE 6.3.5

Expenditure of the Libyan Government

Comparing 1963/64 with 1968/69
(Ordinary Budget)

Head	Current Expenditure 1963/64 (£L'000)	Current Expenditure 1968/69 (£L'000)	Percentages 1963/64	Percentages 1968/69
Interior & Municipal Affairs	6,723	33,806	14.6	20.9
Defence	4,323	14,242	9.4	8.8
Other Administration etc.	4,577	18,397	9.9	11.4
Education	9,059	33,585	19.7	20.7
Health	3,099	13,934	6.7	8.6
Other Social Services	963	5,841	2.1	3.6
Roads	1,834	1,981)		
Posts & Telecommunications	1,854	4,738)	15.4	9.7
Other Communications	3,446	9,098)		
Agriculture	2,687	5,417)	7.2	4.4
Industry & Petroleum	626	1,694)		
Works	2,255	7,147)	7.9	9.1
Housing & State Property	1,391	7,429)		
Miscellaneous	3,299	4,752	7.1	2.8
Total	46,136	162,061	100.0	100.0

(See Appendix 9 for more details)

Source: Census and Statistical Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli, undated. p. 123.

During the first plan period the national economy benefitted more from oil revenues than had been anticipated by those preparing the plan; for example for agriculture £L 29 million was planned while almost £L 38 million was spent on this sector in the development budget 1963-1968 (Table 6.3.4). The ways in which these agricultural allocations were made are shown in Table 6.3.6

TABLE 6.3.6

Allocations within the Agricultural Development Budget 1963-1968

		Expenditure (£L'000)
1.	Agricultural Settlement	7,838
2.	Agricultural Marketing	9,906
3.	Water Resources etc.	4,070
4.	Agricultural Machinery	2,186
5.	Agricultural Credit	11,497
6.	Other	2,254
	Total	37,750

Source: Census and Statistical Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli, undated. p. 125.

Only very inadequate estimates of the dimensions of the government's direct and indirect investment in the study area (the 'Tripoli Triangle') can be made in the absence of official figures. The area was poorly represented in certain of the allocations in Table 6.3.6 which shows the allocations within the agricultural development budget 1963-1968. For example 'agricultural settlement' received comparatively little direct support from the government during the period in the study area compared with other areas. On the other hand government investment in agricultural credit and marketing were probably most beneficial to the farmers of the study area. It is very unlikely that the study area received more than 30% of such agricultural development expenditures, which compares fairly closely with the 36% which it has been estimated that the study area contributed to the gross national income at a period when the figures were less distorted by oil revenues (1964).[33] In addition to this estimated £L 11 million from the development allocations the study area also benefitted from ordinary budget government expenditures of approximately £L 10 million.*

Some measure of how farmers might have been exp ected to have benefitted in the 1963-1968 period can be deduced by relating the £L 21 million of government spending to the number of holdings and the area of such holdings in the study area. For this purpose data from the 1960 national agricultural census have been used, this being the last complete and comprehensive survey of Libyan agriculture.[34] These figures understate both the number of holdings and to a lesser extent the areas irrigated by 1968, in that these have increased as a result of changes in the recent past which have been the subject of this study. It is felt, however,

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* Appendix 9 indicates that between 1963 and 1968 over £L 23 million were allocated to agriculture in the ordinary budget. It is probable that the Tripoli area received a disproportionate amount from this sum, on the basis of the more vigorous character of farming in the area (See Symap 3.14).

that the figures being used in this section are so approximate that little purpose would be served by applying weighting factors to take into account such changes (1961-1968).

Table 6.3.7 indicates the relative proportions of total area, arable land and irrigated land, for the administrative area in 1960 most closely approximating to the study area. On the basis of

TABLE 6.3.7

Number and Area of Holdings of the Administrative Areas Approximating to the Study Area
(Tripoli, Suq al Jumah and Zawiyah)

Administrative Area	No of holdings	Total Area of holdings (ha)	Arable Area (ha)	Irrigated Area (ha)
Tripoli	827	1,910	781	1,090
Suq al Jumah	17,091	276,371	199,352	43,334
Zawiyah	14,720	190,387	131,199	32,612
Total	32,638	468,668	331,332	77,036

Source: Ministry of Agriculture, 1960 Census of Agriculture, Tripol, 1962, p. 52, 53, 60, 61, 67, 512-513.

these figures it can be suggested that during the period 1963-68, government spending contributed £L 643 per holding, £L 45 per hectare of the total holding, £L 63 per hectare of arable land and £L 273 per hectare of irrigated land. Although some of these sums must have gone to cover the costs of government administration, nevertheless it is clear that direct government support to agriculture was of great importance to farmers in the study area, and these direct contributions account for at least one year of the investment per hectare as enumerated by the Joint Project survey (i.e. the 1967-68 agricultural year). The 1967-1968 agricultural year was one of especially heavy investment,

TABLE 6.3.8

Investment per Hectare in the Tripoli and Zawiyah Muhafadat 1967 - 1968

	Sample Size	Total Area of Holdings (Hectares)	Investment £ Libyan per Hectare
Tripoli	77	9852	26.1
Zawiyah	106	3943	51.7

Source: Dasgupta, B.K., 'Investment in Libyan Agriculture' in Penrose, E.T., Allan, J.A. and McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970. p. 140, 151 and 152.

notably in housing which it should be noted was not formally within the terms of the credit and other loan facilities being made to the agricultural community.*

6.3.2 Indirect Government Support to Agriculture

The preceding figures have been concerned with the ways in which government spending has directly affected agriculture compared with other sectors. From our discussions of 'off-farm' employment, (Chapter 3, Section 3.8, and Chapter 5, Section 5.1.3) it has been shown that the Joint Project surveys recorded that between 20% and 50% of farms have additional income from outside the farm, and that much of such employment was in government departments. (See Section 6.2.3) Field enquiry indicated that such income was an important factor with respect to farm investment. 'Off-farm' income was frequently the most important element, for example, in the investment made in housing and irrigation equipment.

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* Housing and related investment accounted for between 16% and 33% of total farm investment in Western Libya 1967/68. See Appendix 10.

A quantification of such indirect support is not possible, but it was clearly of considerable importance. For example, Joint Project survey data show the average investment per farm to have been as follows for the Tripoli and Zawiyah Muhafadat:-

TABLE 6.3.9

Investment per Farm in the Tripoli and Zawiyah Muhafadat 1967/68

	Sample Size	Total Investment per Farm £ Libyan	Investment in Houses and Construction £ Libyan	Other Farm Investment £ Libyan
Tripoli	77	3169	1394	1775
Zawiyah	106	1828	768	1060

Source: Dasgupta, B.K., 'Investment in Libyan Agriculture' in Penrose, E.T., Allan, J.A. and McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970. p. 151 and 152.

These high levels of investment were only partly covered by direct government support which ran at approximately £L 640 per holding as shown in section 6.3.1 for the whole 1963-1968 period.

Other indirect support to farming generally in Libya came through the government's measures to improve the infrastructure of the country. With respect to agriculture, the rebuilding and extension of the road transport network was the most important of such improvements. Even points up to 40 kilometres from Tripoli were by 1968 within easy reach in terms of time of the main markets in Tripoli.

6.3.3 Government Support and the Continuing Development of Irrigated Agriculture

It has been established that agriculture in the study area was expanding and intensifying with respect to irrigated farming. At the same time the consequences of such unregulated development have been made clear in section 6.1.4 of this chapter with respect to underground water resources. In addition it was shown in section 6.2.3 that the upward trend in farm labour wage rates were likely to prove an equally strong negative factor with respect to the long term expansion of labour intensive irrigated farming.

Discounting these problems and looking only at the rate of investment needed to maintain the level of expansion, which government official estimates claimed to be almost 4% per annum at constant prices up to 1968,* it is necessary to use the evidence from the preceding sections (Sections 6.3.1 and 6.3.2) and other material to determine whether the further capital required to bring additional areas under irrigation could come from the existing farm enterprises or whether it must continue to be mainly provided by the government. It should also be noted that another important feature will be discounted, namely that the return on investment in agriculture was the lowest of all comparable business enterprises.[35]

The profitability of farming has been treated to some extent in section 6.1.4, where low rates of turnover were shown to be the rule, (£L 100 - £L 200 per hectare) and this not just because some farmers were waiting for potentially valuable tree crops to mature.

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* This rate of expansion (4%) relates to improvements in agricultural output (see G.D.P at constant prices Table 6.3.1). It is unlikely that the irrigated area has expanded at such a high rate (2% is a more likely figure) but the expansion and intensification of irrigated farming outlined in Chapter 5, section 5.2 would seem to accord with such increases in overall production.

It seems unlikely, therefore, that the agricultural sector itself would be able to generate capital for the expansion of irrigated agriculture. To look at one example in more detail, where the situation was especially difficult.

Stock rearing was being strongly encouraged by the government in 1968, and such activities were closely related to irrigated farming as the fodder crops were often irrigated. At the same time feed subsidies, at half the cost of the feed, meant that much imported feed was being used. An example of the costing of one such enterprise, raising chickens for meat, is interesting. Table 6.3.10 shows that the subsidy for feed was very important, as without it, the loss per bird would have been much more than the profit being earned in 1968. In addition pressures on prices were against the farmer and it was not likely that prices to him could rise.* In this case study therefore

TABLE 6.3.10

The Costs of Raising Chickens - 1968

Farm with 15,000 birds employing two men in work connected with chickens

	£ Libyan per Bird Subsidised	Unsubsidised
Cost of Chicken (imported from Netherlands)	0.055	0.055
Cost of Feed (£L 6 per 100 kg., subsidised to £L 3 per 100 kg) - Each bird eats 4.5 kg in its 9 week life	0.135	0.270
Labour (c. £L 1 per day) - Say £ 15 per week x 9 weeks ÷ 15,000	0.010	0.010
Losses. 100 out of 2500 new chickens die	0.010	0.010
Overheads - plant, buildings	0.010	0.010
Fuel, water, etc.	0.010	0.010
Total cost per bird of rearing	0.230	0.365
Compare Selling price per bird	£L 0.250*	

Source: Personal communication with chicken farmer in the Talbighah/Jadidah area, June 1968.

* By 1971 the price per bird had fallen to £L 0.225

the necessity of government support was clearly necessary especially with respect to the running expenses (direct variable costs) of such chicken rearing enterprises.

It can be concluded therefore that a continuation of the level of government investment in agriculture will be necessary to maintain the expansion and intensification of irrigated farming in the study area. Such intervention will be necessary not only because of the agricultural sector's inability to generate its own investment capital, but also because of another factor not discussed so far. This last related to the other source of investment, the 'off-farm' income which was normally used to renew housing up to 1968. Having improved their dwellings farmers will have the choice, whether to allocate any surplus income* to farm purposes or to alternative consumption. The purchase of consumer durables was increasing rapidly in 1968, and this trend has continued. At the same time there is an increasing awareness that there are water resource problems connected with irrigated farming. It is likely, therefore, that farmers will tend to spend their personal resources on the extension of irrigation works less and less, although at the same time, they might be prepared to use government grants for such purposes. This situation lends further support to the proposition that government policies in support of, and investment in, irrigated farming will alone bring about a continuation in the expansion of such farming. The ordering of such expansion and related policies will be examined in outline in the final chapter.

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* Both farm income and 'off-farm' income.

CHAPTER 7 CONCLUSION

It has not been the purpose of the thesis to identify courses of action with respect to agricultural policy for the study area. Nevertheless in the fairly detailed analysis (Chapters 5 and 6) of those features which the author has considered to be the major physical and economic variables, some apparently unavoidable* problems have emerged which will act against the development of agriculture in the study area, and especially against irrigated agriculture. A natural conclusion, therefore, will be to mention briefly some courses of action which will be consistent with the physical resources of the area and with the supply and remuneration of labour. Since the government directly or indirectly finances almost all development in the country, it will be to the government that these courses of action will be open.

7.1 The Further Development of Water Resources and Related Investment

In the absence of more favourable hydrological information** for the study area, (See Chapter 6, section 6.1.2 and 6.1.3) it must be concluded that there should be no further expansion of irrigated farming, save that supplied with water from other than underground sources.***

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* Certainly unavoidable in the light of present knowledge.

** A hydrological research project commenced in 1971, commissioned by the government. Its scope made it apparent that it was not sufficiently large to more than confirm existing knowledge, and it was unlikely that the research would establish new sources of underground water

*** For example the scheme supplied from purified Tripoli sewage water.

A more drastic, desirable, but certainly unfeasible policy,* would be the reorganisation of irrigated farming spatially, both in terms of extent and disposition, so that the optimum use could be made of the limited underground water resources of north-west Libya. In some areas this policy would require the reduction or termination of irrigated farming, a difficult policy, but not beyond the resources of a rich country.

A desirable preliminary would be research to quantify the extent of the groundwater resources, although it should be remarked that the cost of such research is unlikely to be recovered from the agricultural enterprises which were shown to be feasible, and especially if such developments took place within the economic and institutional structure of Libya likely to obtain in the 1970s.

A further desirable preliminary would be the implementation of a water law to regulate the construction of wells, and to improve water utilisation from existing wells.

In addition there should be regulation of agricultural credit and grants so that new irrigation works are not amongst the enterprises being sponsored by the government.

Finally the schemes to provide the major cities and settlements of coastal Libya with desalinised water should be expedited. Such water could be made available on an economic basis in the urban situation by charging for water.

The resulting reduction in the withdrawal from groundwater would be advantageous with respect to the aquifers, and would in some areas allow a limited additional exploitation of the aquifers for agricultural purposes.

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* Unfeasible for political and social reasons.

7.2 Labour and Wages Policies

Labour costs have been shown to be the major direct variable cost in agriculture (Section 6.2). At the same time the wage rates of all sectors of the economy were, and will continue to be, inter-related. If those responsible for directing the national economy desire that there be viable development of agriculture, the main non-oil, productive* and potentially capital forming sector, then wage rates in other sectors should be consistent with such development. Government wage rates (with related benefits) for unskilled labour were effectively 'leading' the rates in other sectors in 1968 (see Table 6.2.3), which had resulted in increases in wage rates in agriculture and had also adversely affected the supply of unskilled labour in this sector. It would seem that agricultural development will depend on a stable wages policy in the government and a reduction in recruitment to government service.**

At the same time the use of foreign labour from less prosperous Arab countries could be encouraged and its entry and acceptance made more formal than in 1968, with appropriate regulation . As such labour accepts relatively low rates its introduction would contribute to a solution of the labour supply problem without affecting wage rates at the top end of the scale, even in the seasons of peak demand.

The relevance of this last solution seems even more appropriate if other features of the rapidly changing Libyan society are taken into account. A number of factors will make Libyan agricultural labour, as opposed to farm management, even more scarce in future. The rapid

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* 'Productive' including industry, works, and housing, as opposed to administration, defence, social services, transport and communications.

** By 1971 legislation had been passed designed to encourage the early retirement of government employees on favourable terms.

improvement in education and associated urbanisation will tend to deplete further the rural population and labour supply, while the very reasonable, if short term, ambitions and expectations of both the urban and the rural populations will make it progressively less likely that the occupation of 'unskilled agricultural labourer' will attract Libyan labour.

7.3 Other Protection for the Agricultural Sector

It remains to complete this assessment of the measures required to maintain the development of agriculture, consistent with a credible long-term position in the environment of north west Libya, to mention the protection of Libyan agricultural products with respect to foreign competition. At the same time it must be remarked that food imports were increasing rapidly in 1968 (see Figure 2.3.2), and it seemed likely that there would be a continuing strong demand for food products from abroad including both those which are complementary to, and those competitive with, Libyan products.

It will be necessary, therefore, to regulate the import of competitive products, especially fruit, by quotas and tariffs during seasons when the Libyan products are on sale. There was evidence in 1968 that imported fruit from neighbouring Mediterranean countries was more competitive in terms of quality and price than the local equivalent even during the height of such seasons. The prevalence of subsidies to fruit growers in other countries partly explains the low price of the imported products, and would justify a tariff policy in Libya, especially in the light of the relatively disadvantageous level of Libyan agricultural wages

With this concluding discussion of courses of action consistent with the propositions confirmed and tested in the proving of the thesis, some further propositions and suggestions have been made. These will be tested by events, as development takes place in the study area, with its particular environment, and economic and political institutions. Throughout the study the major physical problem has been emphasised as this will undoubtedly be of over-riding importance in the long term development of irrigated farming in north west Libya. At the same time the importance of the economic and institutional constraints have been given proper emphasis, while being sensitive to the rapid changes in the expectations of all levels of Libyan society.

REFERENCES

References are listed according to the serial numbers used in the text.

Each chapter commences with a serial number '1'.

References Chapter 1

All references to ministries refer to ministries of the Libyan government in the period 1966-1968.

1. Census and Statistics Department, Planning Institute, Libyan Arab Republic Survey of National Economy, Tripoli, undated p. 48.

2. Ibid, p. 53.

3. Libyan University - London University Joint Research Project, General Report - Libya, Vol. 3, London 1969, p. 57.

4. Ministry of Agriculture, Census of Agriculture 1960, Tripoli 1962.

References   Chapter 2

1. Hasan, Amari, Local resident. Tribal history at this level is essentially undocumented, and I had to rely on local tradition related to me by Ess. Amari. 1968.

2. Libyan University - London University Joint Research Project, General Report - Libya, Vol. 3, London 1970. p. 127.

3. Theodorou, N. T., Report to the Government of Libya on indigenous and Italian farm enterprises in the Zawia area FAO Report No 259, Rome 1954.

4. Cederstrom, and Bertaiola, Groundwater resources of the Tripoli area, Libya. USOM Report, 1960. p. 33

5. Istituto Geografico Militare Map of the area east of Tripoli showing the extent of irrigated agriculture. Scale 1:50,000 from an original Turkish map at 1:25,000.

6. British Military Administration, Handbook on Tripolitania, 1947. p. 19.

7. Hasan, Amari, op. cit., 1968.

8. Bevin Sforza Agreement 1948. In this British-Italian arrangement it was proposed that 'Tripolitania' would revert to Italy and 'Cyrenaica' would continue to be administered by Britain. These proposals did much to promote Libyan claims for an independent status.

9. Mohamed Oan   Owner of six hectares who also worked for the Oasis Oil Company.

10. Saied Tajuri   Transport contractor working with desert transport for the oil industry and subsequently a farm owner.

11. Penrose, E. T., 'The Economic Setting' in Penrose, Allan and McLachlan, Agriculture and the Economic Development of Libya, London, 1970. p. 1.

12. Ministry of Planning and Development. "Regional gross national income by main sector of economic activity - 1964, provisional estimates" Source : Estimates of the National Accounts Section and Regional Planning Section of the Ministry of Planning and Development. March 1968.

13. Gargour et Fils, Complete wages data for the former Gargour citrus farm, in the east of the Talbighah area.

14. Dasgupta, B. K., Investment in Libyan Agriculture in 'Agriculture and the Economic Development of Libya'. Chapter 5. Table 5.3, p. 142. 1970.

15. Questionnaire survey conducted by the author - 1968.
Farm investment for the year 1967/68
Questionnaire devised by R. Mabro,
administered by the author, and questionnaires
completed by Ramadan Kharfula, Mohamad Suessi
and Sadiq Dahmani.

16. Census and Statistical Department, Ministry of Economy and Trade
(now Min. Planning), <u>Population Census 1954</u>.

17. Census and Statistical Department, Ministry of Economy and Trade
(now Min. Planning), <u>Population Census 1964</u>.

18. Clark, C. and Haswell, M., "The economics of subsistence agriculture"
p. 73, 1966.

19. Ministry of Planning and Development
"Survey of Tripoli families and their income"
1969.
Department of Census and Population
(only seen quoted in press - Libyan Mail, Nov. 1969)

20. <u>Ibid</u>, 1969.

21. Census and Statistical Department, Planning Institute,
<u>Libyan Arab Republic Survey of National Economy</u>,
Tripoli, undated. p. 52.

References Chapter 3

1. Theodorou N.T. Report to the Government of Libya on indigenous and Italian farm enterprises in the Zawia area, FAO Report No. 259 Rome 1954.

2. Ministry of Agriculture Census of Agriculture - 1960, Tripoli 1962, p. 40a ; also Azzoni M.M. and Attiga A.A., Analysis of agricultural data in relation to agricultural production and planning, Technical sub-committee, Draft Five Year Plan, Tripoli 1962.

3. Libyan University - London University Joint Research Project, General Report - Libya, Vol. 3. London, 1970. p. 128.

4. Ibid, pp. 132-133.

5. Ibid, Vol. 1. pp. 145 & 146.

References Chapter 4.

Physical resources

4.1 Climate

1. Thornthwaite, C. W. 'An approach toward a rational classification of climate' Geographical Review 1948 p. 63.

2. Lebenbauer, P. A. 'Growth of maize seedlings in relation to temperature' Physiological Researches Vol I, 1914, pp. 247-288.

3. Meteorological Department, Ministry of Communications Mean monthly and annual rainfall statistics Tripoli, mimeographed records, undated, approximately 1960.

4. Graif, G. L. 'Contributo alla cerealicoltura libica' Agricoltura Libica Gen. 1941, No. 1, pp. 1-31.

5. Veihmeyer, F. J. 'Some Factors Affecting the Irrigation Requirements of Deciduous Orchard' Hilgardia 2 1927, pp. 250-251.

6. Penman, H. L. 'The Dependence of Transpiration on Weather and Soil Conditions'. Journal of Soil Science 1. 1949, pp. 74-89.

7. Mitchell, P.K. The Moisture Characteristics of the Maltese Climate, Durham 1959.

8. Veihmeyer, F.J. op. cit. p. 254.

9. Penman, H. L. op. cit. p. 83.

10. Stanhill, G. 'The Concept of Potential Evapotranspiration in Arid Zone Agriculture' UNESCO Symposium Montpellier (Methodology of Plant Eco-Physiology) 1965, pp. 109-117.

11. Mitchell, P. K. op. cit.

12. Veihmyer, F. J. op. cit., pp. 250-251.

13. Thornthwaite, C.W. 'A Re-examination of the Concept and Measurement of Potential Evapotranspiration'. John Hopkins University, Laboratory of Climatology CLIMATOLOGY Vol. 7, No. 1, 1954, pp. 200-209.

14. Crowe, P. R. Some Further Thoughts on Evapotranspiration : a New Estimate. Geographical Studies Vol. 4, No. 1., p. 56-75.

15. Peters, D. B. 'Growth and Water Absorption by Corn as Influenced by Soil Moisture Tension, Moisture Content and Relative Humidity'. Proc. Soil Sci. Soc. Amer. Vol. 24, No. 6, p. 523-526.

16. Stanhill, G. 'The Concept of Potential Evapotranspiration in Arid Zone Agriculture' UNESCO Symposium Montpellier (Methodology of Plant Eco-Physiology) 1965, pp. 109-117.

17. Stewart, J. H. Land and Water Resources in Tripolitania USOM Report, Tripoli, 1960, preceding page 176.

18. COTHA Amenagement de l'Uadi Megenin : Rapport Général for the Libyan Public Development and Stabilisation Agency 1954.

19. FAO Agricultural Production Yearbook Yield data for wheat, barley 1955-1968.

20. Maximov, N. A. Plant Physiology revised 1947, p. 128.

21. Kramer, P. J. 'Measurement of water stress in plants'. UNESCO Arid Zone Research XXV 1965, pp. 343-351.

4.2 Underground Water

22. Desio, A, 'Sulla posizione geologica e sull'origine delle falde aquifere artesiano della Gefara ' in 1st di Geologia di Milano, Publ. No 13, Milan, 1940. p. 333.

23. Cederstrom and Bertaiola Ground-water resources of the Tripoli area, Libya USOM Report 1960, p. 21.

24. Ibid Table 6, pp. 56-57.

25. Hill, R. W. 'Underground water resources of the Jefara Plain'. in Willimott and Clarke Field Studies in Libya 1960, p. 12.

26. FAO Report on Agriculture in Libya, 1952.

27. HILL, R. W. op. cit. p. 13.

28. Niccoli, E. and Casini, V. 'La chimica delle acque artesiane della Libia'. Gli Annali dell'Africa Italiana III, 1940, pp. 259-278.

29. Todd, D. K. Ground-water hydrology 1959, pp. 1647.

30. Desio, A. a) 'Le acque profonde della Libia e la loro importanza per l'agricoltura' Reg. Inst. Agr. - Firenze 1940 XVIII, p. 5.

b) 'Verso la Solizione del problema delle acque profonde in Libia'. Rivista Libia Anno II, No. 7, 1938, p. 3-8.

31. Desio, A. op. cit., 30a, 1940, p. 4.

32. Libyan Ministry of Planning and Development - Statistics Department External Trade Statistics 1958-1967.

4.3 Soils

33. Willimott, S. E. [handwritten: G.] 'Soils of the Jefara' - Field Studies in Libya - Durham 1960, p. 30.

34. Principi, P. I principali tipi di suolo della Tripolitania. Firenze 1947, p. 5.

35. Willimot, S. G. op. cit., Table 4, p. 43, Durham, 1960.

36. Della Gatta, L. Analisi di terreni della Tripolitania Firenze 1933, p. 1

37. Willimott op. cit. p. 31.

38. Willimott, S. G. Memorandum on groundnut investigations in Tripolitania, Libya. Durham 1958.

Chapter 5 References

1. British Military Administration. Handbook on Tripolitania, Tripoli, 1947. Appendix I p.77.

2. Cederstrom & Bertaiola, Groundwater Resources in the Tripoli Area, Libya, U.S.O.M./U.S.E.S. Tripoli, May 1960 (Fieldwork from 1956-1960)

3. Stewart, J. H., Land and Water Resources of Tripolitania, U.S.O.M. Tripoli, July 1960.

4. Gargour et Fils, Wages Records, 1952-1968 in the authors' possession.

5. LULUJRP. Investment data 1967/68 for Farm 185, Gargour et Fils.

6. Hill, R. W., Ph.D Thesis Agriculture and Irrigation on the Tripolitania Jefara, Durham, 1960. Farm Studies Appendix, Study No. 3. p. 489.

7. Ibid, p. 489.

8. Allan, J. A., Investment data for Farm 902, SACIA, 1967/68. Collected by the author.

9. Mohamed Oan: Farmer informant and land owner in the Talbighah/ Jadidah case study area.

10. Mohamed Oan: personal communication.

11. Mohamed Oan: personal communication.

12. Allan, J. A., Inventory and investment data collected by the author.

13. Fairey Surveys Ltd. Stereosopic air photo cover of the Gefara Plain. Scale 1:24,000. Also Mosaics sheets 1,2,3 and 4, and Bir-el-Ghan Development Area, Feb-May, 1953.

14. Aero Exploration. Stereoscopic air photo cover of parts of the Gefara Plain. Scale 1:65,000, Film Nos. L71 and L73, Prints 0398-0425, 0500-0518, 0525-0535. May 1966.

15. Hunting Surveys Ltd. Stereoscopic air photo cover, Tripoli and Suwani bin Yadim, Scale 1:20,000, Job No 53966, Print 2995-3015 and 2862-2868. June 1968.

16. Aero Exploration. Stereoscopic air photo cover of the Talbighah/ Jadidah area. Scale 1:20,000, Prints 0073-79 Feb 1968.

17. Libyan University-London University Joint Research Project. General Report, Vol. 1, Agriculture and the Economic Development of Libya, 1970. p. 86.

18. Ibid, p. 87.

19. Fairey Surveys Ltd. op. cit. Mosaic 4.

20. Libyan University-London University Joint Research Project, Vol. 2, 1970. Crop Survey Maps 3 & 4 & Table 4, p. 16.

21. Ibid, Table 4, p. 16.

22. Ibid, Crop Survey Map 3.

23. Fairey Surveys Ltd., op. cit., 1953, Prints 3029-3031 & 3005-3007.

24. Aero Exploration, op. cit., 1968. Prints 0073-0078.

25. Fairey Surveys Ltd., op. cit., June 1953. Mosaic 2.

26. Aero Exploration, op. cit., May 1966. Print 525.

27. Libyan University-London University Joint Research Project, General Report, Vol. 2 Maps, 1970. Maps 1 & 3.

28. Harman, H. H., Modern Factor Analysis, Chicago, 1968.

29. Cattell, R. B., 'Factor Analysis : an Introduction to Essentials I & II Biometrics Vol 21, pp. 190-215; 405-435.

30. King, L. J., Statistical Analysis in Geography, New Jersey, 1969.

31. Ahmad, Q., Indian Cities : Characteristics and Correlates, Chicago, 1965.

32. King, L. J., op. cit.

33. Adelman, I and Morris, C. T., Society, Politics and Economic Development : A Quantitative Approach, Baltimore, 1967.

34. Libyan University-London University Joint Research Project, General Report, Vol 2 Maps, 1970, Maps 1 & 3.

35. Ibid, Maps 3 & 4.

36. Ibid Unpublished questionnaire data.

Chapter 6 References

1. Stedman-Davies, Middle East Agricultural Development Conference Papers (Figures for Israel) 1944.

2. Tofani, Genio Rurale, 1955, quoting Perdisa (Figures for Italy).

3. Binnie, Deacon and Gourley, Report to the government of Iraq Development Board, Zad Irrigation Project. Vol I.

4. Cederstrom, D.J. and Bertaiola, M., Groundwater resources of the Tripoli area, Tripoli, 1960, p. 51.

5. Stewart, J.H., Land and Water Resources of Tripolitania, Tripoli, 1960.

6. Clark, C., The economics of irrigation, Oxford (Pergamon) 1967. p. 57.

7. Ibid, p. 58, Table 20.

8. Hill, R.W., 'Underground water resources of the Gefara' in Willimott, S. E. and Clarke, J. I. (editors), Field studies in Libya, Durham, 1960. p. 23.

9. Clark, C., op. cit, p. 64.

10. Personal communication with Mr A. Gargour, Tripoli, 1968.

11. Stippler, H. H., Farming in the Mudiria of Ulad Awen - A pilot study, Ministry of Planning Report, March, 1970. p. 16.

12. Ibid, p. 16.

13. Mabro, R. E., 'Employment and Wage Rates' in Penrose, E.T., Allan, J.A. and McLachlan, K. S., Agriculture and the Economic Development of Libya, London, 1970. p. 164.

14. Mohamed Said Muftah Budheir - personal communication Oct. 1968.

15. LULUJRP - unpublished data relating to wages for 371 farms in the Western Provinces, London, 1968.

16. Seers, D., 'The Mechanism of an Open Petroleum Economy' in Social and Economic Studies 13(2) 1964.

17. Census and Statistical Department, Ministry of Economy and Trade, General Population Census 1964, Tripol, 1966. p. 58.

18. Census and Statistical Department, Ministry of Economy and Trade, Employment in the Petroleum Mining Industry in Libya 1964, Tripoli, 1966. p. 2.

19. Mabro, R. E., 'Labour Supplies and Labour Stability, a Case-Study of the Oil Industry in Libya' in Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 32 No 4, 1970. p. 321.

20. Ibid, p. 321

21. Mabro, R. E., Field-work carried out during February and March 1967 in Tripoli and Benghazi.

22. Mabro, R. E., 'Labour Supplies and Labour Stability, a Case Study of the Oil Industry in Libya' in Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 32, No 4, 1970. p. 327.

23. Ibid, p. 327.

24. London University- Libyan University Joint Research Project, Final Report, Vol. 3, London, 1970. pp. 117.

25. Ibid, p. 112.

26. Unpublished data from the 1967 survey of the Libyan University - London University Joint Research Project, London, 1970. Tabulations of data.

27. Mabro, R. E., Bulletin of Oxford Institute of Economics and Statistics, 1970, op. cit. p. 325.

28. Mohamed Said Muftah Budheir - personal communication, Oct. 1968.

29. Mohamed Said Muftah Budheir - personal communication, June, 1971.

30. Hasan Amari - personal communication, June, 1971.

31. Wages records for a large farm near Tripoli, copies of which are available in the Department of Geography, SOAS, University of London, W.C.1.

32. Bank of Libya, Economic Bulletin, Tripoli, May - June, 1970. Table 22.

33. Ministry of Planning and Development, Regional Gross National Income of Libya by Main Sector of Economic Activity, 1964, Tripoli, 1968. p. 1-2.

34. Ministry of Agriculture, 1960 Census of Agriculture, Tripoli, 1962. p. 52, 53, 60, 61, 67, 512-513.

35. A. Gargour - personal communication.

APPENDIX 1

THE SYMAP PROGRAMME - COMPUTER MAPS

1.1 Introduction

A number of computer maps have been produced in the process of analysing the data collected by questionnaire survey, and a selection of these maps is reproduced in this thesis to show the geographical distributions of various basic farm characteristics, as well as to illustrate important inter-relationships, for example the distribution of modern irrigation equipment with the location of ex-colonist farms.

The maps have been extremely useful as 'tools' in writing the descriptive and analytical material in Chapters 2 and 3. Those reproduced have been photographically reduced to improve visual interpretation, and to permit the inclusion of more material.

1.2 The Data - refer to the map on the following page.

In July 1968 a questionnaire survey was conducted throughout the settled agricultural areas of the Western Provinces. As well as collecting information with reference to farm investment, labour, wages, and migration, more than 30 items relating to farm inventory were also recorded. The survey utilized a systematic sampling technique in which data points were selected at the intersections of grid lines (Universal Transverse Mercator Grid) two kilometres apart, as shown on the US A.M.S. P761 Series, 1:50,000. In some areas a ten kilometre grid was adopted, where farming was discontinuous, dispersed and carried out by dry farming methods, as for example on the Gefara and Jabal areas, totalling approximately 25% of the total. The US A.M.S. maps were a convenient and suitable basis for sample point selection, and proved excellent for map reading purposes in the field.

Some 450 farms were selected and visited in Western Libya, from which 371 complete and adequate sets of individual farm data were obtained. Of the 450 farms, 51 were found to have been selected either on large farms for which data had already been enumerated at another grid intersection or where agriculture was no longer carried out. 28 completed questionnaires were found to be unreliable when checks were carried out in the Tripoli office of the Joint Project (LULUJRP), and these have been rejected.

The study area for this thesis lies partly in the Muhafadah of Zawiyah and partly in the muhafadah of Tripoli. 184 farms were successfully enumerated in these two administrative areas, and the data for these farms has been cited as evidence to support the propositions in the thesis. The symaps used to illustrate Chapter 3 were compiled from the same data for the Tripoli Triangle proper, that is excluding the outlying 'islands' of agricultural activity around Zuwarah in the west of the Zawiyah muhafadah and Qasr al Qarahbulli in the east of the Tripoli muhafadah.

Since coordinate references of all farms were recorded, and finally coded on punch cards along with the other farm data, these data could readily be used in a programme for the production of computer maps, a method known as SYMAP, devised in the Laboratory of Computer Graphics at Harvard University.

1.3 An Explanation of SYMAP

The Synagraphic Mapping System (SYMAP) is a computer programme which allows the graphic output of spatially distributed data, after complex computer manipulation of these data.*

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* Professor Howard T. Fisher of the Laboratory of Computer Graphics, Harvard University was responsible for the production of the SYMAP 'package'.

The programme is devised to operate with a standard line printer, which permits the use of standard computer equipment but has the disadvantage that the symbolisation possible from such a printer is limited.** However, by overprinting the normal typographic characters of the line printer, it is possible to produce an acceptable range of contrasting symbols with an increasing density of tone where this is desirable.

The type of map used for the study area is of the 'Contour' type ; that is, it is based on the interpolation by the computer of 'slopes', by means of complex weighted averages. For each 1/8 inch by 1/10 inch position of the line-printer, reference is made to surrounding data points, and a symbol of the required density is printed out, the mathematical relationship of which is consistent with the nearest data points. Such extensive manipulation is only possible in a computer, and the map print-out which requires only a few further seconds saves many hours of cartography and interpretation.

A transparent overlay has been used in the final reproduction of the maps, to show details of coast, settlement and roads, and to assist in the interpretation of the maps. Legends and place names can be printed by the line-printer within the limits of its symbolisation, but the overlay method permitted easier map interpretation, neater presentation, and added little to the total effort and cost, since one overlay was sufficient for all maps, with the exception of legend detail.

** Robertson, J. C., 'The Symap Programme for Computer Mapping', Cartographic Journal, December 1967, pp. 108-113.

Comparison of Temperature and Humidity Data for Stations Relevant to the Areas of Detailed Study - Talbighah & Suwani bin Yadim

	J	F	M	A	M	J	J	A	S	O	N	D	Annual	No of Years of Obs'tions	No of Kilometres From Coast
TEMPERATURES															
EXTREME MINIMUM °C															
Tripoli	-0.6	0.2	2.2	4.4	6.1	9.0	13.4	15.0	13.2	9.4	5.2	1.4	-0.6	34	0
Idris/B.Gashir	-1.2	0.0	1.6	3.6	6.5	9.6	11.9	13.1	12.1	6.7	2.8	0.1	-1.2	14	20
Aziziyah	-3.2	-2.7	-0.8	1.0	4.8	8.3	8.2	10.4	11.0	5.5	1.3	-1.4	-3.2	30	40
EXTREME MAXIMUM °C															
Tripoli	28.1	34.0	40.4	40.5	44.2	44.7	46.0	45.6	45.0	39.7	36.2	28.4	46.0	34	0
Idris/B.Gashir	31.5	39.6	40.8	45.1	45.4	48.5	49.4	50.6	49.5	43.8	39.6	29.6	50.6	14	20
Aziziyah	30.4	34.8	44.5	48.3	49.5	51.9	51.0	51.0	49.6	49.0	37.8	32.4	51.9	30	40
MEAN MINIMUM °C															
Tripoli	7.6	8.6	10.4	13.1	15.7	19.1	21.0	21.7	20.9	17.8	13.3	8.9	14.8	34	0
Idris/B.Gashir	5.3	6.3	8.1	10.6	13.8	17.2	18.4	19.2	18.2	15.7	11.2	6.7	12.6	14	20
Aziziyah	5.4	6.5	8.6	11.6	15.2	18.5	20.0	20.1	19.2	16.2	11.4	6.8	13.3	30	40
MEAN MAXIMUM °C															
Tripoli	16.1	17.9	20.0	23.1	25.4	28.4	30.1	30.8	30.1	26.9	23.1	18.2	24.2	34	0
Idris/B.Gashir	18.2	19.9	23.4	27.5	30.2	34.9	36.8	36.9	34.5	30.9	24.5	18.8	28.0	14	20
Aziziyah	17.5	19.7	23.0	27.5	31.2	35.4	37.4	37.6	35.8	31.2	24.2	19.1	28.3	30	40
MEAN MONTHLY °C															
Tripoli	11.8	13.3	15.2	18.1	20.6	23.7	25.6	26.2	25.5	22.4	18.2	13.6	19.5	34	0
Idris/B.Gashir	11.7	13.1	15.8	19.0	22.0	26.1	27.6	28.0	26.4	23.3	17.8	12.8	20.3	14	20
Aziziyah	11.5	13.1	15.8	19.6	23.2	27.0	28.7	28.8	27.5	23.7	17.8	12.9	20.8	30	40
HUMIDITY (%)															
Tripoli	62	61	60	59	62	63	65	65	64	60	61	62	60	34	0
Idris/B.Gashir	57	55	51	43	43	40	41	45	47	50	57	60	49	14	20
Aziziyah	61	58	53	45	41	37	40	44	50	50	56	61	50	21	40

Source : Ministry of Communications, Meteorological Department. Monthly and Annual Climatological Data for Libya, Tripoli, c. 1962 (undated).

APPENDIX 2.2

Diurnal/Annual Relative Humidity

To illustrate the difference between coastal and inland stations

		S	O	N	D	J	F	M	A	M	J	J	A	Mean Annual	No. of km. from coast
		Relative Humidity as Per Cent													
Tripoli	Mean Daily	63	60	61	62	62	61	60	59	62	63	65	65	62	0
	9 a.m.	55	55	59	62	58	63	57	54	61	59	63	62	60	
	3 p.m.	68	59	56	54	68	57	61	61	69	70	71	69	63	
Bin Gashir	Mean Daily	47	50	57	60	57	55	51	43	43	40	41	45	49	20
	9 a.m.	59	63	67	72	69	69	62	53	50	48	53	59	60	
	3 p.m.	37	43	48	53	42	44	39	31	33	33	31	30	39	
Aziziyah	Mean Daily	50	50	56	61	61	58	53	45	41	37	40	44	50	40

From 1. Meteorological Office 'Aviation meteorology of route Castel-Berrito - Cairo' Met. reports no 5. London HMSO, 1950. pp. 26-28.

2. Ministry of Communications, Meteorological Department, Monthly and Annual Climatological Data for Libya, Tripoli, c. 1962 (undated).

Temperature Records Tripoli Airport - 1953 to 1968 - to Show the Extremes of Temperature Affecting Areas 20 Kilometres from the Coast in the Study Area

Degrees Centigrade

EXTREME MINIMUM

	J	F	M	A	M	J	J	A	S	O	N	D
1953	1.1	1.7	2.2	5.0	9.4	12.2	17.2	16.1	13.9	12.8	7.8	4.4
1954	1.1	-0.6	2.8	3.9	6.7	13.9	12.2	13.9	15.0	10.6	5.6	1.7
1955	3.9	4.4	2.2	6.7	10.6	11.1	13.3	16.1	15.6	10.6	5.0	5.0
1956	3.3	0.0	2.2	3.9	6.7	10.6	14.4	14.4	14.4	8.9	3.3	2.8
1957	1.7	2.2	0.6	3.9	7.8	12.8	14.4	15.0	15.0	10.6	3.9	3.9
1958	0.0	1.0	3.0	3.0	5.0	12.0	15.0	17.0	12.0	10.0	7.0	3.0
1959	3.0	2.0	5.0	5.0	6.0	10.0	13.0	16.0	17.0	9.0	6.0	2.0
1960	1.0	3.0	4.0	4.0	8.0	13.0	15.0	16.0	15.0	13.0	8.0	1.0
1961	4.0	3.0	3.2	5.5	8.4	13.7	15.7	16.0	15.4	10.3	7.4	2.5
1962	4.7	3.0	6.0	5.0	8.4	11.6	12.6	14.0	11.8	12.0	2.8	3.8
1963	0.9	1.3	1.0	4.5	8.4	12.0	17.0	17.8	16.8	9.7	4.2	5.4
1964	3.2	2.3	2.3	4.6	9.0	15.5	14.3	16.6	12.9	6.6	6.6	1.3
1965	3.7	0.9	1.3	4.2	6.5	10.8	16.5	15.0	13.5	12.4	5.0	5.0
1966	3.6	0.6	3.4	7.2	9.8	10.6	16.0	16.4	16.0	13.6	4.2	2.0
1967	1.3	2.4	3.6	4.0	8.0	12.1	15.0	17.4	15.4	12.6	7.0	1.4
1968	2.0	1.2	3.2	9.4	9.4	14.0	14.4	17.0	14.0			

MEAN MINIMUM

	J	F	M	A	M	J	J	A	S	O	N	D
1953	4.9	5.8	7.1	13.3	13.5	20.8	20.7	20.0	20.4	17.8	11.6	9.0
1954	4.9	5.4	9.8	11.2	13.1	20.0	17.9	18.2	18.4	14.2	11.0	8.3
1955	7.6	9.9	8.2	12.1	16.6	19.2	21.3	21.9	20.5	16.4	12.8	9.0
1956	7.6	5.5	8.0	12.1	14.1	19.1	20.4	18.6	19.5	14.2	10.4	6.6
1957	6.4	6.5	7.7	12.3	15.0	20.7	18.3	19.7	19.1	16.6	11.1	7.6
1958	5.6	6.6	8.8	10.5	15.1	20.5	19.5	20.1	17.4	16.0	12.8	8.6
1959	6.8	6.6	9.4	10.9	15.6	18.5	18.0	21.5	21.9	15.0	10.6	7.3
1960	5.6	7.9	9.5	12.1	17.5	20.3	21.3	22.4	19.7	19.1	12.4	8.2
1961	6.9	6.6	7.7	12.6	15.6	18.6	19.9	19.3	18.6	15.3	13.4	8.1
1962	8.0	7.3	10.6	13.2	15.7	17.9	20.1	18.1	19.0	17.0	13.0	7.8
1963	7.4	7.2	6.7	12.2	13.3	19.3	21.5	21.6	20.7	15.2	12.0	10.6
1964	6.4	7.3	9.8	11.8	14.3	20.1	18.5	22.4	16.4	15.5	11.7	7.8
1965	6.5	5.2	8.6	9.8	12.7	16.7	21.9	20.5	20.2	17.0	10.6	9.2
1966	7.6	7.7	9.0	12.5	14.5	19.6	20.5	21.5	19.1	18.1	11.4	5.2
1967	5.2	6.9	8.5	11.6	15.7	18.3	18.2	20.3	20.1	15.7	12.6	6.0
1968	6.0	8.2	9.6	14.0	18.4	18.7	19.6	22.1	19.8			

EXTREME MAXIMUM

	J	F	M	A	M	J	J	A	S	O	N	D
1953	20.0	27.2	25.0	37.8	39.4	45.0	45.0	41.1	39.4	39.4	24.4	29.4
1954	21.7	23.3	37.2	40.0	42.8	45.0	47.2	41.1	38.9	31.1	30.6	24.4
1955	28.9	33.3	38.3	33.3	42.8	43.9	47.2	48.3	40.0	38.9	34.4	26.1
1956	27.2	23.3	28.9	43.9	42.2	46.1	46.7	41.1	38.3	33.9	35.0	18.9
1957	18.9	31.7	30.6	35.6	43.9	46.1	42.8	42.2	41.1	37.2	32.8	27.2
1958	23.0	28.0	38.0	37.0	42.0	45.0	44.0	45.0	45.0	40.0	29.0	26.0
1959	23.0	26.0	33.0	38.0	42.0	42.0	43.0	47.0	45.0	32.0	30.0	27.0
1960	26.0	35.0	33.0	26.0	43.0	43.0	47.0	47.0	43.0	38.0	35.0	27.0
1961	23.0	19.2	32.0	36.8	43.6	41.6	43.7	40.4	39.8	39.1	33.9	27.4
1962	27.8	26.2	34.3	37.4	43.0	45.4	45.4	38.6	38.0	38.5	31.7	25.8
1963	29.2	26.2	30.8	34.2	34.4	43.7	43.2	44.0	44.6	36.5	33.2	28.6
1964	19.8	31.2	35.4	36.4	40.6	46.5	41.2	45.0	34.8	39.0	36.9	24.0
1965	27.5	29.2	34.0	38.0	41.2	42.4	45.9	44.2	43.2	34.2	31.6	26.4
1966	26.3	35.3	28.4	27.1	41.9	44.4	45.5	46.8	38.6	36.6	29.0	22.0
1967	24.6	29.4	32.0	36.2	39.3	46.5	41.0	43.0	38.0	38.4	33.0	25.0
1968	23.0	34.0	32.4	36.2	42.6	43.0	42.0	47.0	44.0			

MEAN MAXIMUM

	J	F	M	A	M	J	J	A	S	O	N	D
1953	14.1	18.2	18.3	28.8	28.3	36.4	36.2	33.8	34.7	30.2	21.3	20.4
1954	15.9	17.7	23.2	25.2	28.0	36.0	32.5	33.3	33.6	25.9	22.4	18.0
1955	20.7	23.3	24.1	23.4	32.1	33.2	37.5	36.2	33.2	29.7	24.8	20.1
1956	20.0	17.5	20.2	27.1	28.4	33.3	36.5	34.8	33.4	26.9	23.2	16.4
1957	15.5	21.2	21.1	25.1	28.2	35.2	33.4	35.6	32.6	27.3	22.2	17.3
1958	15.5	20.2	22.9	25.3	31.1	35.1	34.2	36.4	31.8	28.6	22.0	20.1
1959	16.8	17.3	23.2	26.1	29.6	33.6	33.4	35.8	35.1	26.8	22.5	18.3
1960	18.2	23.7	23.9	24.0	31.0	34.1	34.8	37.2	32.4	31.7	26.3	17.1
1961	15.9	16.9	19.0	26.4	31.1	33.3	34.4	33.1	32.3	28.4	27.6	19.8
1962	17.8	17.2	22.3	26.1	30.8	31.9	36.5	33.5	33.4	28.3	22.6	15.9
1963	18.9	19.2	20.9	24.6	25.5	34.7	36.2	36.5	32.9	25.1	25.5	22.4
1964	15.6	19.2	24.4	25.4	29.3	34.0	33.1	36.5	30.4	29.9	22.7	18.9
1965	17.0	17.1	20.4	24.4	28.6	33.3	39.0	35.0	33.2	29.4	24.9	19.5
1966	18.9	23.8	19.0	25.8	28.7	34.7	36.0	38.0	31.7	29.8	22.2	17.0
1967	16.7	19.5	27.5	26.1	30.5	31.4	33.6	36.2	32.7	28.5	24.8	17.6
1968	16.0	21.3	22.7	27.5	32.0	35.5	32.5	37.2	33.6			

Source: Ministry of Communications, Meteorological Department, Unpublished Records, Tripoli.

APPENDIX 2.4

Ghibli Winds

Frequency

1928-1938

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Average Per Year	No. of Km from Coast
Sidi Al Misri (5 Km West Talbighah)	0	0.3	0.3	0.2	0.1	1.4	2.1	2.0	7.3	1
Aziziyah	2.9	1.0	1.0	0.1	1.2	2.4	4.4	3.9	13.7	40

Source : GRAIF, G.L. "Contributo alla cerealicoltura libica" Agricoltura Libica. Gen. 1941 No. 1 pp. 1-31.

Mean Monthly and Annual Rainfall Data for Stations Relevant to the Total Study Area

and the Areas of Detailed Study ; Tripoli, Talbighah, Airport/Bin Gashir, Suwani bin Yadim & Aziziyah

	J	F	M	A	M	J	J	A	S	O	N	D	Annual	No of Years of Obser'ns	No of Km From Coast
	MINIMUM RAINFALL												MIN		
Tripoli [1]	4.6	0	0	0	0	0	0	0	0	0	0.7	1.0	163.5	60	0
Talbighah(Gargour) [2]	Insufficient Data												-	8	2
Airport/B.Gashir [2]	0.3	0	0	0	0	0	0	0	0	0	0	3.0	151.6	32	20
Suwani bin Yadim [2]	2.0	0	0	0	0	0	0	0	0	0	0	0	111.0	14	20
Aziziyah [1]	5.5	0	0	0	0	0	0	0	0	0	2.1	0	78.7	13	40
	MAXIMUM RAINFALL												MAX		
Tripoli [1]	209.6	161.9	260.4	41.6	23.8	15.0	10.7	28.1	93.5	196.1	233.1	377.7	758.3	60	0
Talbighah(Gargour) [2]	Insufficient Data													8	2
Airport/B.Gashir [2]	151.8	136.7	97.5	67.2	19.6	16.8	8.2	21.4	109.4	134.7	101.7	211.1	547.1	32	20
Suwani bin Yadim [2]	182.0	67.8	73.0	83.0	15.0	4.0	0	0	76.0	102.0	107.0	96.0	484.0	14	20
Aziziyah [1]	97.2	106.4	39.4	56.8	13.1	28.0	0	1.0	18.7	112.3	91.0	83.7	359.8	13	40
	MEAN RAINFALL [2]														
Tripoli	73.4	40.6	23.5	10.9	5.2	1.3	0.5	0.6	9.7	36.2	64.9	95.1	361.9	84	0
Talbighah(Gargour)	53.9	31.7	15.3	19.3	2.9	0.2	0	0	6.2	34.3	50.3	83.7	297.8	13	2
Airport/B.Gashir	60.0	43.1	22.2	12.5	3.4	1.4	0.2	0.9	8.1	25.6	40.7	69.3	287.4	36	20
Suwani bin Yadim	51.1	33.2	14.0	12.8	1.6	0.5	0	0.1	6.0	25.1	42.2	57.7	244.3	29	20
Aziziyah	44.3	30.9	19.4	11.5	4.0	1.2	0.1	0.1	5.5	18.5	24.5	49.8	209.8	46	40

Sources : 1. Fantoli, A, Le Piogge della Libia, Roma, 1952.

2. Ministry of Communications, Meteorological Department, Monthly and Annual Climatological Data for Libya, Tripoli, c.1962 (undated).

Rainfall Data for Tripoli and Suwani bin Yadim
1953 - 1968

Millimetres of Rain

		J	F	M	A	M	J	J	A	S	O	N	D
Tripoli	1953	123.4	9.1	14.8	1.5	15.0	0.1	0	1.4	0	33.1	186.7	113.8
	1954	14.4	11.6	7.7	6.5	1.1	5.0	0	0	0	33.9	48.5	199.2
	1955	0.5	51.3	16.5	52.3	0	0	0	0	3.4	70.9	46.4	54.1
	1956	15.9	42.4	30.1	0	0	0	0	0	8.6	14.4	29.9	100.7
	1957	136.3	0.2	6.2	33.5	22.0	4.0	0	0	0.3	114.8	39.5	112.3
	1958	28.9	14.0	21.5	5.7	0	0	0	0	0.9	15.7	119.5	57.5
	1959	34.4	66.2	8.0	0	2.7	0	0	0	0	13.5	37.9	73.5
	1960	26.6	6.1	5.1	55.7	1.0	0	0	0	53.5	3.0	40.9	208.2
	1961	45.9	28.3	36.8	47.1	9.5	0	0	0	1.0	22.7	0	35.8
	1962	113.1	82.7	18.6	3.0	5.0	0	0	0	0	27.7	17.8	88.6
	1963	50.1	7.8	7.3	16.3	0.5	0	0	0	61.8	99.2	10.9	5.9
	1964	140.7	28.0	0.2	8.4	0	0.5	0	0	0	4.3	51.3	32.3
	1965	48.5	38.4	26.3	11.9	0.9	0	0	0	15.6	13.7	19.0	42.4
	1966	3.9	3.8	48.0	32.4	0	0	0	0	1.8	71.9	21.7	122.7
	1967	57.3	16.0	49.2	1.7	24.3	5.6	0	0	3.5	30.4	33.6	38.9
	1968	35.6	41.2	0.3	7.6	0.2	7.4	0	0	1.3	N		
Suwani bin Yadim	1953												
	1954												N
	1955	2.5	53.0	0	83.0	0	0	0	0	0	31.5	9.5	93.0
	1956	2.0	43.0	25.5	0	0	0	0	0	9.5	30.7	4.7	54.0
	1957	122.0	0	3.5	42.5	15.0	3.5	0	0	5.5	97.0	35.5	62.0
	1958	7.0	2.3	27.5	0	0	0	0	0	4.5	15.0	107.0	57.0
	1959	32.5	54.8	14.5	5.5	0	0	0	0	0	31.0	16.5	44.0
	1960	5.5	4.8	3.0	21.5	0	0	0	0	6.0	0	27.0	71.0
	1961	17.5	17.0	21.0	24.0	0	0	0	0	11.0	7.0	0	7.0
	1962	105.0	67.8	15.0	N	3.0	0	0	0	2.0	27.5	27.0	96.0
	1963	39.0	11.0	10.0	16.8	0	0	0	0	76.0	102.0	41.0	0
	1964	182.0	76.0	0	3.0	0	4.0	0	0	0	9.0	29.5	2.0
	1965	26.5	28.0	13.0	3.0	0	0	0	0	10.0	4.0	5.0	38.0
	1966	19.0	N	35.0	74.0	0	0	0	0	15.0	30.5	47.0	65.0
	1967	75.0	10.5	73.0	3.0	5.0	4.0	0	0	6.5	27.0	17.0	41.0
	1968	44.5	34.5	20.0	18.0	0	0	0	0	0			

Source: Ministry of Communications, Meteorological Department, Unpublished Records.

N = NO DATA

TABLE 1

Rainfall Data Showing the Decline of Precipitation with Distance from Tripoli

Mean Monthly & Mean Annual Rainfall - Millimetres West to East from Tripoli															
Station	Distance From Tripoli	Period of Readings(Years)	J	F	M	A	M	J	J	A	S	O	N	D	Total
Tripoli	0	84	73.4	40.6	23.5	10.9	5.2	1.3	0.5	9.6	9.7	36.2	64.9	95.1	361.9
Suq al Jumah	4 km	47	68.6	38.7	28.4	12.1	4.0	0.9	0.5	0.6	9.0	30.9	67.9	83.3	344.9
Talbighah(Gargour)	10 km	13	53.9	31.7	15.3	19.3	2.9	0.2	0	0	6.2	34.3	50.3	83.7	297.8
Tajura	13 km	19	51.6	29.7	15.8	14.2	2.8	0.9	0	0.5	7.8	33.1	58.1	75.9	290.4

(Source: Ministry of Communications, Meteorological Department. "Monthly & Annual Climatological Data for Libya", Tripoli)

TABLE 2

Rainfall for the Year 1939 - Millimetres West to East from Tripoli															
Tripoli	0 km	1	45.4	59.4	27.3	8.4	3.7	0	0	0.2	2.5	0	123.4	26.6	297.0
Suq al Jumah	4 km	1	32.0	61.5	22.5	5.5	2.5	0	0	0	0	0	87.6	23.3	234.9
Mellahah(n. of Talbighah)	8 km	1	25.0	39.0	18.1	20.9	2.8	0	0	1.0	4.0	0.5	28.0	52.0	191.3
Tajura	13 km	1	96.1	28.7	43.5	12.0	0	0	0	?	?	?	49.4	38.5	(268.6)

(Source: A. Fantoli, "Le Pioggie della Libia" 1952 p. 299)

TABLE 3

Total Annual Rainfall(mm) at Stations East of Tripoli for the Period 1952-1967																	
(Readings in mm for Sept to Aug)		52/53	53/54	54/55	55/56	56/57	57/58	58/59	59/60	60/61	63/62	62/63	63/64	64/65	65/66	66/67	67/68
Tripoli	0 km	260.7	397.9	402.2	263.2	355.8	337.0	304.9	219.4	473.2	281.9	216.1	355.6	213.9	178.8	366.6	198.7
Suq al Jumah	4 km	-	-	-	-	226.9	222.5	-	188.4	303.0	219.0	224.5	408.6	143.5	-	-	-
Talbighah(Gargour)	10 km	-	-	-	-	-	-	-	-	428.0	253.0	248.0	356.0	261.0	223.0	-	-
Tajura	13 km	-	-	423.5	281.0	271.3	240.5	213.4	176.0	366.8	249.0	241.3	369.5	198.2	214.0	341.8	192.5

(Source: Ministry of Communications, Meteorological Department Unpublished Records)

TABLE 4

Mean Monthly & Mean Annual Rainfall - Millimetres North to South from Tripoli															
	Distance From Tripoli	Period of Readings(Years)	J	F	M	A	M	J	J	A	S	O	N	D	Total
Tripoli	0 km	84	73.4	40.6	23.5	10.9	5.2	1.3	0.5	0.6	9.7	36.2	64.9	95.1	361.9
Suwani bin Yadim	21 km	29	51.1	33.2	14.0	12.8	1.6	0.5	0	9.1	6.0	25.1	42.2	57.7	244.3
Aziziyah	41 km	46	44.3	30.9	19.4	11.5	4.0	1.2	0.1	0.1	5.5	18.5	24.5	49.8	209.8

(Source: As for Table 1 Above)

TABLE 5

Total Annual Rainfall (mm) at Stations South of Tripoli for the Period 1953-1967																	
		52/53	53/54	54/55	55/56	56/57	57/58	58/59	59/60	60/61	61/62	62/63	63/64	64/65	65/66	66/67	67/68
Tripoli	0 km	260.7	397.9	402.2	263.2	355.8	337.0	304.9	219.4	473.2	281.9	216.1	355.6	213.9	178.8	366.6	198.7
Suwani bin Yadim	21 km	-	-	-	-	285.4	236.8	290.8	126.3	183.5	212.8	229.3	484.0	185.5	219.5	362.0	208.5
Aziziyah	41 km	-	122.4	206.3	133.3	197.0	150.4	165.6	125.9	188.7	251.5	315.5	450.1	193.3	226.3	231.1	-

(Source: As for Table 3 Above)

APPENDIX 2.8

Water Balance - Malta

Assuming Soil Moisture Storage Capacities of 63 mm, 102 mm, 152 mm
and a Mean Annual Rainfall of 520 mm

(Compare Tripoli 362 mm)

	S	O	N	D	J	F	M	A	M	J	J	A	Annual	
Moisture Surplus		2	46	61	56	25								
Moisture Deficiency	94						8	41	87	127	170	165	497	
SMR Soil Moisture Recharge		2	46	15									63	63 mm Capacity
WS Water Surplus				46	56	25							127	
SMU Soil Moisture Utilisation							8	41	15				64	
D Deficiency	94								71	127	170	165		
SMD Soil Moisture Deficit	63	61	15	0	0	0	8	41	63	63	63	63		
SMR		2	46	54									102	102 mm Capacity
WS				8	56	25							89	
SMU							8	41	53				102	
D	94											165		
SMD	102	98	53	0	0	0	8	48	102	102	102	102		
SMR		2	46	61	43									153 mm Capacity
WS					13	25								
SMU							8	41	86	18				
D	94									109	170	165		
SMD	152	152	150	104	42	0	0	8	48	135	152	152		

Source: Mitchell, P. K., Studies in the Agrarian Geography of Malta, Durham 1958.

APPENDIX 3

LITHOLOGIES OF WELLS IN THE TRIPOLI AREA
WITHIN OR CLOSE TO THE AREAS OF DETAILED STUDY
(See Map Appendix 3.3)

3.1 Talbighah and the Surrounding Area

3.1.1 Well Number 338, 1.3 kilometres east-southeast of main gate of Tripoli Air Force Base

(Altitude 11.2 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Fine sand	4.1	4.1
Soft Grey limestone	1.1	5.2
Hard Packed fine sand	3.6	8.8
Light grey limestone	2.2	11.0
Soft yellow to brown sandy clay	13.1	24.1
Soft light brown limestone . Water	3.6	27.7
Soft light grey limestone	0.6	28.3
Stiff light blue sandy clay	2.4	30.7
Soft light grey limestone	7.0	37.7
Soft light grey sandy clay	4.5	42.2
Soft white chalky clay	2.7	44.9
Soft light yellow clay	6.1	51.0
Soft light grey limestone . Salt Water	7.4	58.4
Soft white limestone	10.3	69.7
Soft light blue sandy clay	0.1	70.1
Grey shell rock	5.7	76.4
Stiff yellow clay	1.2	77.6

3.1.2 Well Number 345 - on former concession (Conc. Bigiorno), opposite northeast gate of Tripoli Air Force Base, Mellahah

(Altitude 6 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Slightly clayey sand	4.5	4.5
Soft reddish limestone. Water at 6 metres Static level 5.5 metres below surface	12.5	17
Friable sandy marl	5	23
White and grey limestone	12	35
White to yellow spongy-textured limestone Water at 37-55 metres	39	74
Somewhat sandy blue clay	27	101
Fossiliferous grey marly limestone . .	3	104
Plastic lay, water in spongy limestone at 259-260 metres (slight flow)and at 308-310 metres (slight flow).	338	442
Compact fossiliferous limestone . . .	5.5	447.5
Somewhat friable white quartz sandstone Water. Static level 57 metres above surface, flow 100 cu.m./hr.	45	482.5
Quartz, sand and gravel with large oyster shells. Water. Static as above, flow 300 cu.m./hr.	1.5	484

Source for 3.1.1 and 3.1.2 : Cederstrom, D. J. & Bertaiola, M., Ground-water Resources in the Tripoli Area, Libya, Tripoli, 1960 p.179.

3.1.3 Well Number 348, Guastella Well Field at east end of field, Tripoli Air Force Base

(Altitude 11 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Fine sand	1.8	1.8
Light grey sandy clay with pieces of limestone	5.2	7.0
Hard light brown limestone	1.3	8.3
Light grey to brown sandy clay with pieces of limestone	5.4	13.8
Stiff light brown sandy clay	4.8	18.6
Soft grey sandstone . Water	11.0	29.6
Dark grey sandy clay	4.5	34.1
Soft light grey limestone	14.7	48.8
Soft light limestone . Salt water . . .	.082	49.6

Source : as for 3.1.1, p. 180.

3.1.4 Well Number 379, Jadidah (Sghedeida) Well Field 8.9 kilometres from Tripoli on Tripoli-Homs road

(Altitude 22.3 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Fine sand	1.8	1.8
Light brown limestone	5.8	7.6
Very hard dark gray limestone	2.1	9.7
Soft dark gray sandstone	4.7	13.7
Compact silty sand	4.9	18.6
Light grey sandy clay	1.5	20.1
Light grey limestone	1.5	21.6
Dark grey sandstone. Water	5.1	26.2
Hard dark grey sandstone	1.8	28.0
Yellow limestone. Water	1.6	29.6
Yellow sandy clay	1.4	31.0
Sticky blue clay	3.1	34.1

Source : as for 3.1.1 p. 182.

3.1.5 Well Number 388 - Jadidah Nursery, Ministry of Agriculture, Jadidah

(Altitude 22.4 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Brown fine sand	8	8
White sandy limestone (caliche?).	6.5	14.5
Fine brown sand	4.5	19
Light brown sandy limestone	6.2	25.2
Compact white limestone	6.5	31.7
No sample . Water	7.2	38.9
Yellow Marl	2.3	41.2
Grey clay	4.3	45.5
Fine brown sand	1.5	47
Grey clay	5.5	52.5

Source : Christie, A. M., Geology of the Gharyan Area, Tripoli, 1965. pp. 27-28 (Well constructed 1953)

3.1.6 Well Number 360A on former concession (Conc. SACIA) 1 kilometre south of kilometre 11.2 on Tripoli-Homs road

(Altitude 22.4 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Friable red sandy limestone	4	4
Soft yellow limey quartz limestone	14	18
Soft white sandstone. Water. Static level 18 metres below surface	6.5	24.5
Compact yellow limestone. Water at 32-34 metres. Static level 15 metres below surface	9.5	34
Very sandy marl	10	44
Compact quartz sandstone.	4	48
Spongy-textured limestone	4	52
Fossiliferous green sandy clay	7	59
Fossiliferous white spongy-textured . limestone.	18.5	77.5
Fossiliferous green clay	11.5	89
Sandy limestone	2	91
Fossiliferous sandy clay	15	106
Green clay, Sandy in lower portion, limestone strata at 147-151, 160.5-163 and 182-187 metres. Water at 206 metres, salty, static level 8.5 metres below surface . . .	130	236
Fossiliferous clayey limestone breccia . . .	16.5	252.5
Green sandy clay	7	259.5
Pebbly sand and clay. Salty water small flow	10.5	270
Clay with fossiliferous nodules	7	277
Grey clay	15	292
Spongy-textured fine sandy limestone. Salt Water. Static level 12 metres above surface, flow 8 cu.m./hr	4	296
Fossiliferous very sandy marl	10	306
Fossiliferous sand and clay	3	309
Very sandy marl	18	327

Source: as for 3.1.1 p. 181.

3.1.7 Well Number 449, Sarraco Well Field 3.4 kilometres southeast of Mellahah Junction on Tripoli-Homs road

(Altitude 62 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Hard limestone	.5	.5
White sandstone	1.5	2
Clayey sand	3	5
Red sand	1	6
Sandy clay	7	13
Hard red limestone	1.5	14.5
Sandstone	5.5	20
White sand and sandstone	7.6	27.6
Yellow plastic clay	5.4	33
Yellow sandstone. Water	3	36
Sandstone. Water	19	55
Conglomerate	1	56
Clay	6	62

Source : as for 3.1.1 p. 183

3.1.8 Well Number 520 on Former Italian farm Azienda Ostuni, 1.5 kilometres south-southwest of Kilometre 27 on Tripoli-Homs road

(Altitude 4 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Dune sand	10.5	10.5
Nodular clayey limestone ("Conglomerato")	11.5	22
White clay and layers of limestone. Water at 22 metres. Static level 22 metres . .	13.5	35.5
Sand. Water. Static level 21.5 metres . . .	1	36.5
Sandy material	5.5	42
Marly clay	28	70
Grey clay	17	87
Fossiliferous plastic clay.	38.5	126.5
Blue marl	13	139.5
Clay with hard limestone layers	9.5	149
Clay and shell rock	54	203
Intercalated sand and clay. Brackish water at 203 metres	24	227
Sandy clay with pyrites	12	239
Fossiliferous sandy material	12	251
Sandstone (?). Water. Static level 20 metres above surface, flow 120 cu.m./hr. .	9	260

Source : as for 3.1.1 p. 185

3.1.9 Well Number 538 Former Italian Farm Azienda FATMA, 4 kilometres east of Aya Zarah Penitentiary

(Altitude 68 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Sand with limy cement	7.5	7.5
White limestone.	3.5	11
Marly to floury limestone. Water at 23 and 32 metres. Static level 26.2 metres below surface	34	45
Yellow limy marl.	6	51
Marly to sandy limestone	8	59
Grey clay	4	63
Green to yellow limestone	13	79
Green clay	2	81
Sandy limestone, becoming marly or floury with depth	22	103
Green somewhat sandy clay, pyritiferous fossiliferous in lower portion	46	149
Green marly clay with much pyrite	2	151
Marly limestone with sandy and pyritiferous layers	2	153
Green clay, marly in places	27	180
Marly limestone, with pelecypods and oysters.	14	194
Green marly clay, a little pyrite at 204-209 metres	19	213
Green marl with occasional fossils	3	216
Marl.	3	219
Hard fossiliferous limestone	8	227
Green clay	1	228
Soft white limestone	4	232
Green marly clay	5	237
Grey sandy marl	12	249
Green clayey and limy sand	1	250
Green slightly sandy clay	17	267
Green limy and clayey sand	9	276
Slightly marly green clay	24	300
White limy quartz sandstone, echinoids, oysters and lamellibranchs and some pyrites at 349.5-352 metres and echinoids at 352-359 metres. Water (log indicates water is fresh but this is questioned here). Static level 5 metres below surface, at 300 metres.	59	359
White very fine limy quartz sand. Water. Static level 5 metres below surface. Yield, from basal 10 metres of sandstone above and upper 9 metres of this sand, 100 cu.m./hr. with 9 metres of drawdown	12.5	371.5

Source : as for 3.1.1 pp. 185-186

3.1.10 Well Number 556B Aya Zarah Penitentiary

(Altitude 49.5 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Red sand	3	3
Silica sand	5	8
Sandstone	3	11
Clayey caliche ("tin")	1.5	12.5
Limestone with beds of clay	13.5	26
Yellow clayey limestone	18	44
Limestone	5	49
Soft limestone with beds of green clay . .	9	58
Green clay	5.5	63.5
Green clay with beds of limestone	9.5	73
Hard and soft beds of limestone	22	95
Green clay, lower portion sandy and fossiliferous	69	164
Fossiliferous	21	185
Green clay	21	206
Soft limestone, gray clay	24	230
Green clay	14	244
Clay with beds of soft limestone	7	251
Green clay, and fossiliferous grey limestone. Water Flow 1-1/2 cu.m./hr . .	19	270
Siliceous sandy clay	6	276
Green clay	9	285
White sand. Water. Flow 12-1/2 cu.m./hr. .	3	288
Green clay with beds of soft limestone . .	57	345
Siliceous sand and intercalated clay. Water. Flow 10 cu.m./hr.	12	357
Green sandy clay	13	370
Hard limestone	4	374
Limestone with beds of sandy clay	8	382
Hard and soft limestone	8	400

Source : as for 3.1.1 p. 187.

3.2 Suwani bin Yadim Area

3.2.1 Well Number 815, Former Italian Concession. (Conc. Soltocasa)

3 kilometres west northwest of Suwani bin Yadim

(Altitude 56 metres)

Lithologic description	Thickness (metres)	Depth (metres)
Friable calcareous quartz sandstone more compact below 21 metres. Water. Static level 1 metre below surface	37	37
White quartz sandstone with limy cement.	2	39
Light marly sandy limestone with strata of red fossiliferous sandstone	33	72
White sandy limestone ; spongy-textured, friable, clayey and fossiliferous . . .	13	85
Yellow limy and sandy marl	65	150
Friable yellow marly limestone	8	158
Very sandy marl	16	174
Gravelly quartz sand	2	176
Green clay, slightly sandy, with large oysters	19	195
Brecciated limestone with friable clayey cement	20	215
Slightly sandy green clay with small pebbles	27	243
Green clayey sand	8	251
Plastic green clay	16	277
Fossiliferous limestone with travertine.	3	280
Plastic green clay	5	285
Very spongy brecciated limestone. Salt Water. Static level 11.8 metres above surface	6	291
Green slightly sandy clay	20	311
Friable porous brecciated limestone . .	7	318
Sandy and marly clay with thin spongy-textured limestone and sand strata. . .	67	385
Grey sandy marl	6	391
Fine clayey sand	13	404
Clayey sand. Salt Water. Static level 11.8 metres above surface, flow small. . . .	16	420
Very friable red quartz sandstone . . .	17	437
Pudding stone gravel and sandstone beds with small agate pebbles	26	463
Red very clayey sandstone.	1	464

Source : as for 3.1.1 p. 189

APPENDIX 4 WATER QUALITY RECORDS FOR WELLS IN THE TRIPOLI AREA
WITHIN OR CLOSE TO THE AREAS OF DETAILED STUDY (See Map Appendix 4.3)

4.1 <u>Talbighah and the Surrounding Area</u>

Analysis of Groundwater.

Well Number	334	346	351	359	360A	360B	361	368	383
Location	el-Cherma	Mellahah	Guastella	Conc. S.A.C.I.A.	Former Conc. S.A.C.I.A.	Former Conc. S.A.C.I.A.	Former Conc. S.A.C.I.A.	Jadidah	Jadihah
Depth (metres)	34	34	18	28	327	200	21	8	62
Silica (SiO_2)				35	29	45			
Iron (Fe)	tr	.08	tr	0.0	0.0	.0	.05		.08
Calcium (Ca)	56	165	48	242	22	379	33	76	37
Magnesium (Mg)	26	134	27	75	14	78		47	24
Sodium (Na)				418	949	609			
Potassium (K)				42	34	54			
Bicarbonate (HCO_3)	210	195	100	398	960	406	156	196	182
Sulfate (SO_4)	62	432	77	720	17	1,080	28	75	62
Chloride (Cl)	138	1,510	145	596	1,060	885	48	369	53
Nitrate (NO_3)				4	6	5		41	
Hardness as $CaCO_3$	247	960	240	914	114	1,270	232	381	199
Dissolved Solids	520	3,200	580	2,390	2,620	3,400	330	1,000	355
Specific Conductance at 25°C (micromhos)	819	4,910	820	3,160	4,390	4,680	456	1,540	500
Date Collected	Jan. 1957	Feb. 1957	Feb. 1957	July 1957	July 1957	July 1957	Jan. 1957	June 1957	Jan. 1957

Source : Cederstrom, D. J. and Bertaiola, M., Groundwater Resources of the Tripoli Area, Libya.
Tripoli, 1960, p. 200-201

4.1 <u>Talbighah and the Surrounding Area (continued)</u>

Analysis of Groundwater

Well Number	430	447	448	449	539	556A	556B	556B	556B
Location	Saracco	Belashar	Belashar	Saracco	Ayn Zarah	Ayn Zarah Penitentiary		Ayn Zarah Penitentiary	
Depth (metres)	62	7	7	15	56	57	278	357	400
Silica (SiO_2)						12			14
Iron (Fe)	tr	.11	.08	.0	.0	.0			tr
Calcium (Ca)	35	109	126	31	31	33			126
Magnesium (Mg)		61.5	163	15	15	16			101
Sodium (Na)						27			393
Potassium (K)						3			40
Bicarbonate (HCO_3)	206	207	245	162	170	179	159	160	407
Sulfate (SO_4)	65	455	269	20	27	15	336	435	628
Chloride (Cl)	75	1,106	2,020	44	42	50	425	500	578
Nitrate (NO_3)					16	30			tr
Hardness (as $CaCO_3$)	202	697	990	141	141	149	580	720	732
Dissolved solids	404	2,600	4,536	255	260	276	1,600	1,850	2,080
Specific Conductance at 25°C	643	3,978	6,552	423	412	439	2,425 a/	2,800	2,920
Date Collected	May 1957	Feb. 1957	Feb. 1957	July 1957	June 1957	July 1957	Apr. 1956	Apr. 1956	July 1957

Source : as 4.1 previously. pp. 202-204.

4.2 Suwani bin Yadim and the Surrounding Area

Analysis of Groundwater

Well Number	763	772	783	787	796	802	804	805	815	834
Location	Bin Gashir	Bin Gashir	Suwani bin Yadim			Suwani bin Yadim		Suwani bin Yadim		
Depth	39	53	34	30	30	44	32	27	28	44
Silica (SiO_2)									7.0	13
Iron (Fe)	.0	.0	.0	.0	tr	tr	tr	.11		tr
Calcium (Ca)	52	83	56	78	148	144	122	381	126	147
Magnesium (Mg)	32	54	27	41	85	95	83	282	26	96
Sodium (Na)										189
Potassium (K)										7
Bicarbonate (HCO_3)	227	217	200	199	265	236	262	311	258	234
Sulfate (SO_4)	110	230	86	154	442	394	369	1,460	410	409
Chloride (Cl)	99	195	89	163	319	319	209	823	180	386
Nitrate (NO_3)	43	53	27	50						48
Hardness (as $CaCO_3$)	260	432	249	366	761	740	645	2,110	665	762
Dissolved solids	525	980	478	680	1,420	1,400	1,300	3,550	1,272	1,414
Specific Conductance at 25°C	819	1,521	742	1,053	1,920	1,990	1,760	4,680		
Date Collected	June 1957	June 1957	June 1957	June 1957	March 1956	March 1957	March 1957	March 1957	Dec. 1956	July 1957

Source : as for 4.1 pp. 206-208.

APPENDIX 5

UNDERGROUND WATER LEVELS IN THE AREAS OF DETAILED STUDY

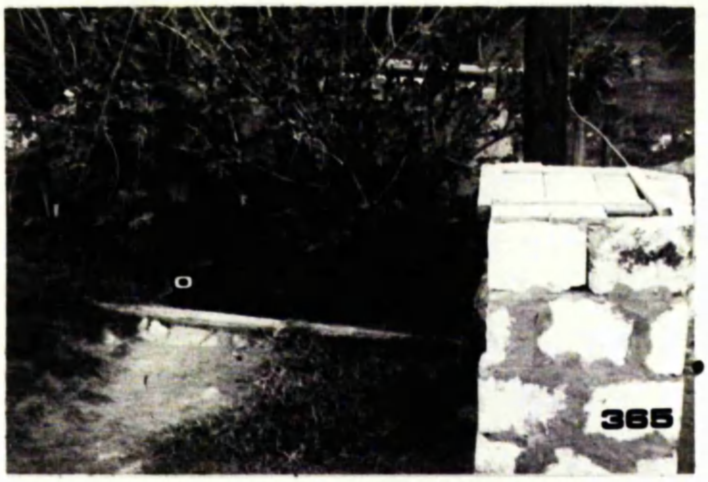
5.1 Water Well Records, Talbighah 1957-1968

5.2 Data for Well No 420, Talbighah, Showing Drawdown Following Pumping and Seasonal and Long Term Trends in Underground Water Levels

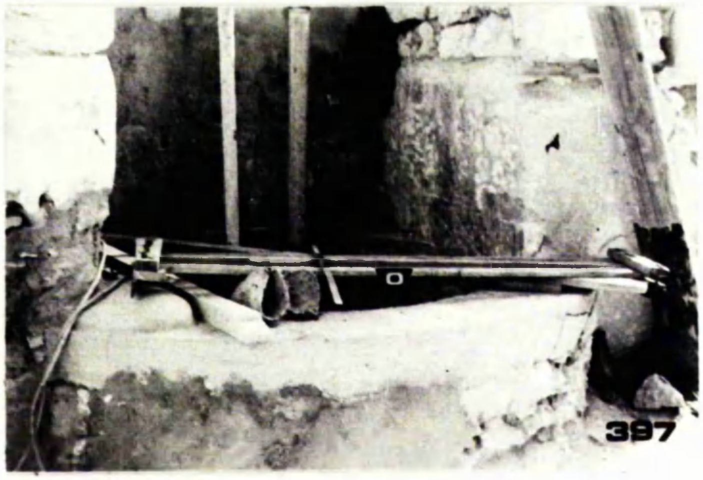
WELLS TALBIGHAH

Underground water levels recorded

1967-68



Depths recorded to this point



See Fig 4.2.2 for well locations

APPENDIX 5.1 Water Well Records Talbighah 1957-1968

Well* No	Km From Coast	Elevation AMSL	Well Depth	Type	Date Well Made	Deepened (m)	Metres to Water: Winter/Spring	Summer	Autumn	Date Measured: Winter	Summer	Autumn	Pump N.P.	Yield M^3/HR	Hours Since Pumped	Hectares	Draw-Down	Annual Discharge (m^3)	Decline /Year	Remarks
365	3.5	8.4	9	Dug	1917	0	5.70			1.57			–	30	–	5		70,000		Salem Artib Sold to Has. M.
							6.01			12.3.68			2	–	>24	"		–	0.03	Krema(Well Dry after 3 hrs
								6.80			27.7.68		2½	–	3days	"		–		Pumping 1957)
									6.59			12.10.68	2½	–	>24	"		–		
397	4.5	18.2	52	Drill'd	1945	Pump lowered	15.20			1.57			–	13	–	2½		30,000	0.07	Owner Mon.Jarush Throughout
						15	15.94			12.3.68			2	–	½	"		–		Only Pumped 10min Prev 24hrs before
						c.1966		(21.76)			27.7.68		2	–	Pumping	"		–		Pumping – Heavy Use for Tomato Factory
									16.47			12.10.68	2	–	11	"		–		
400	4.7	27.4	57	Drill'd	1927	0	23.80			2.37			4&4	4	–	P/180		1,500	0.04	Owner Gargour
							24.23			15.3.68			"	–	2	"		–		
								25.85			28.7.68		"	–	¼	"		–		Pumped ½hr only Prev 12 hours
									26.57			15.10.68	"	–	¼	"		–		
406	5.4	26.2	–	Drill'd	1953	0	–			–			10	–	¼	P/180		–	–	Owner Gargour
								21.41			28.7.68		10	–	¼	"		–		
									21.79			15.10.68	10	–	¼	"		–		
409	5.5	27.2	23	Drill'd	1953	0	16.50			2.57			10	80	–	P/180	5.5	250,000	0.04	Owner Gargour
							16.91			15.3.68			10	–	3 hrs	0	–	–		By 1968 not used for irrigation
								17.14			28.7.68		10	–	12	0	–	–		-Goes Dry soon after Pump
									16.84			15.10.68	10	–	½	0	–	–		Starts (1968)
411	6.2	34.6	–	Drill'd	1953	0	–						10	–	–	P/180	–	–		
							22.83			15.3.68			10	–	6	"	–	–	–	
								24.69			28.7.68		10	–	12	"	–	–		
									25.54			15.10.68	10	–	¼	"	–	–		
420	6.6	40.8	31	Drill'd	–	–		16.40			17.7.59		–	–	–	4	–	65,000		Owner Said Muftah Budher
134-							21.50			27.12.56			–	32	–	21	–	–	0.26	
420							23.17			9.4.60			–	–	–	"	–	–		
(350-								22.10			69.60		10	–	–	"	0.70	168,000		A Second Pump & Well Have
1317-							25.32			12.3.68			10	80	16	"	"	(80/hr	0.52	Been Installed on the Farm
1-9)								26.28			28.7.68		10	"	11	"	"	x8200)		-Same Discharge or Larger
									24.9			12.10.68	10	"	12	"	"			since Hourly Rate is 120m^3/hr

* Well Number of Cederstrom D. J., Groundwater Resources of the Tripoli Area, Libya, Tripoli, 1960

C – Reported by the owner P – Indicates part of the total area of the Farm

Source : 1957-1960 Measurements by Cederstrom, D. J., as above, in Tables of Well Records published with the report
1968 Measurements by the author

APPENDIX 5.2 Data for Well Number 420, Talbighah, Showing Drawdown Following Pumping, Seasonal and Long Term Trends in Underground-water Levels

Well* No	Km From Coast	Elevation (AMSL)	Well Depth	Type	Date Well Made	Deepened	Metres to Water			Date Measured			Pump N.P.	Yield M³/hr	Hours since Pumped	Hectares	Draw Down	Annual discharge (m^3)	Remarks
							Winter/ Spring	Summer	Autumn	Winter Spring	Summer	Autumn							
420 1374-420 (3250-1317-1-9)	6.6	40.8	31	Drill	-	-	25.31			10.3.68			10	80	$1\frac{1}{2}$	21	0.70	168,000 (80/hr x8x200)	Owner Said Muftah Budher
							25.32			12.3.68			10	80	16	"	"		
							26.07			13.3.68			10	80	Pumping for $2\frac{1}{2}$hrs	"	"	"	

The above figures indicate that drawdown at this well was 0.7 metres in 1968, and that recovery is rapid. The owner reported that the well recovered in less than 15 minutes. Such a pattern was also reported on nearby farms.

As above	6.6	-	31	Drill	-	-	25.32			12.3.68			10	80	16	21	0.70	168,000	As above
								26.28			28.7.68		10	80	11	"	"		
									26.49			12.10.68	10	80	12	"	"		

These figures indicate that the seasonal decline in water-level at this well in 1968 was 1.2 metres between the spring high-level and the autumn low. During the later part of the period there was no significant precipitation at the coast or on the Gefara prior to 12th October, the date of the last reading.

As above	6.6	-	31	Drill	-	-		16.40			17.7.39		10	32	-	-	-		Owner ?
								22.10			6.9.60		10	32	-	-	-	65,000	Owner Camizzo Biaggio
								26.28			28.7.68		10	80	11	21	0.70	168,000	Owner Siad Muftah Budher

Showing the decline in the water-level since 1939. The rate of decline is higher after 1960.

* Cederstrom. D. J., and Bertaiola, M. <u>Ground-water Resources of the Tripoli Area</u>, Tripoli, May 1960.

Source : Cederstrom, D. J. as above <u>Tables of Well Records</u>, Tripoli, 1960 p. 68. and Author's fieldwork.

APPENDIX 6

6 Fieldwork Methods - Hydrology and Ground and Photogrammetric Survey

6.1 Data Collection with Reference to Underground-water Levels

Although very useful data were available over a number of years for observation wells, in or very near the two areas of detailed study (Fig 42.2), it was realised that confirming data were required from other locations to establish the homogeneity of the areas or to identify trends within them.

In order to accomplish this, the original field records of the groundwater survey carried out by Cederstrom ("Underground water resources in the Tripoli area", 1960) were searched out and consulted in the Soil and Water Resources Department of the Ministry of Agriculture in Tripoli. These fortunately were still in existence, and it was possible not only to be sure that one had located the correct well, but also that if check measurements were taken one would be using the same datum from which to measure down to the water.

In carrying out my first measurements I was advised by Professor Carlyle Grey, a hydrologist and Professor of Geology at the University of Libya. The method adopted was to lower a metal tape down the well and just into the water, weighted by a plumb-bob. The last few metres of the tape had been chalked so that the water level was clearly visible when the tape was drawn up. By subtracting the length of wetted tape from the total distance measured to the datum at the top of the well, the depth from datum to water surface was recorded accurately. Adjustments between ground level and measuring datum were then made.

Other factors which were relevant to the position at the well at the time of the recording were also made, most important the time since pumping. The time and date of the measurement were recorded and also the pump size, and its output if known.

As far as possible measurements were made after at least one hour had eleapsed since pumping, and in almost all cases recordings were made twelve hours after pumping had ceased, that is at between 6.30 am and 7 am, before the pumps had been switched on for the day.

A copy of a sample of a field sheet is included as the next page of this appendix.

6.2 Aerial Survey and Ground Control Work Completed at Suwani bin Yadim and Talbighah

Aerial photography

Air photos were taken of both field areas in order to establish patterns of land-use and changes in rural housing.

Stereoscopic cover was flown at 1:20,000 for both areas, and enlarged screened positives were made of the areas in which I was particularly interested. Land use maps, crop maps and maps showing housing have all been produced, after the examination of the stereoscopic cover.

The opportunity of producing a closely contoured map of the Talbighah area was also taken. Six height control points were established on three overlaps and levelled in. The levelling run was thirteen kilometres in length, and was completed in October 1969. The survey was supervised by Mr L. L. S. Williams of Hunting Surveys Limited.

The heights of wells, and a dense cover of spot heights were established on a Thomson-Watt Plotter in the department of photogrammetry of University College, London. From this information it was possible to produce the one metre contours and the groundwater surface on Figure 6.1.4 in Chapter 6.

At the time of writing there is no similar map of the area, and such precise detail was essential in order to establish the height of the water table above sea-level, and to determine how close to sea-level heavy pumping depressed groundwater levels. The significance of drawing down the 'cone of depression' to below sea-level is fully explained in chapter 6.

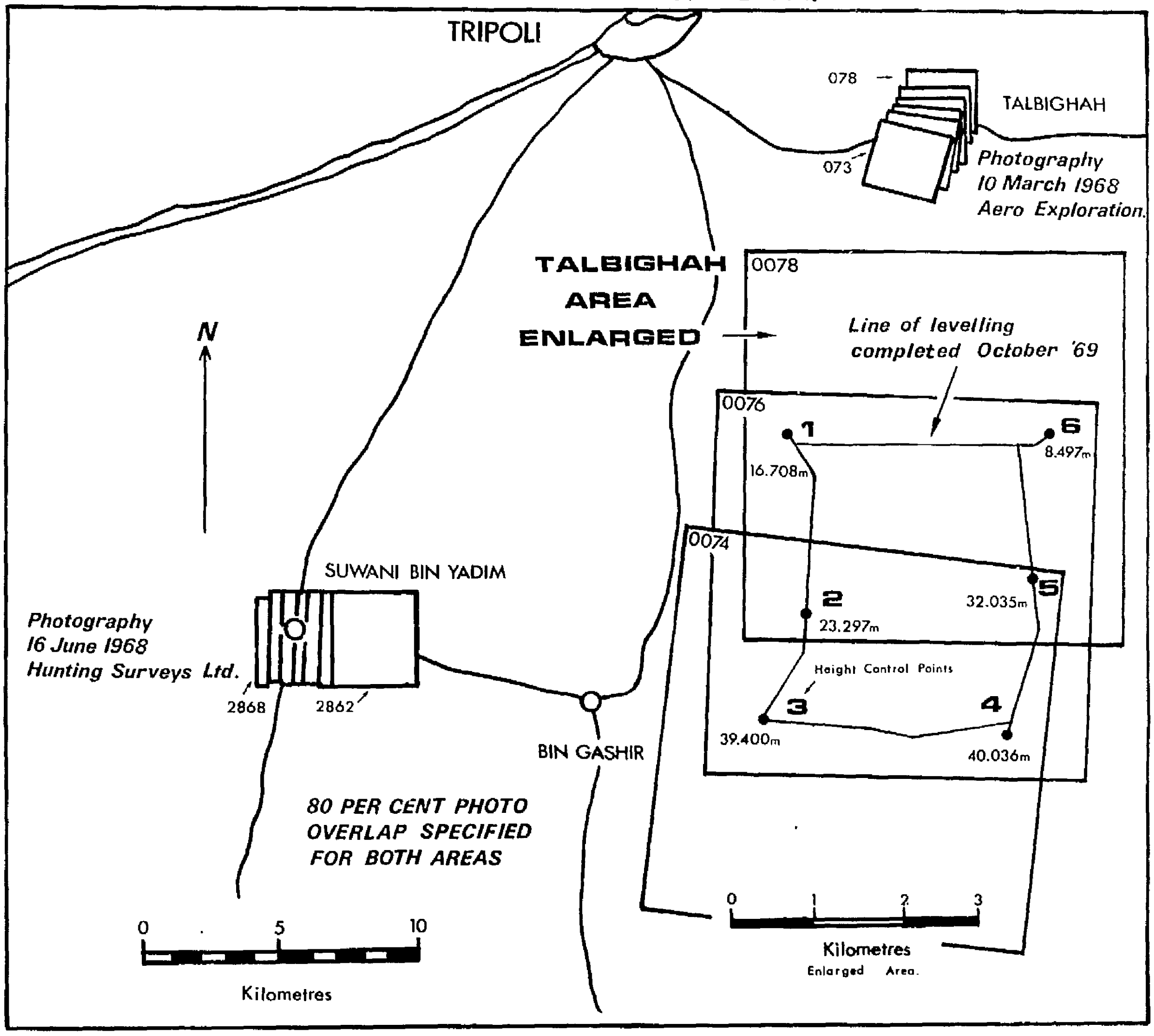
A diagram is included showing the locations of the height control points and the positions of the levelling lines run between them.

Details of air photographs

Talbighah	Flown by Aero Exploration of Frankfurt, West Germany
	Photo scale 1:20,000
	Vertical 80% overlap
	Direction of flight - South to North
	Date 11.2.68
Suwani bin Yadim	Flown by Hunting Surveys Ltd, Boreham Wood, England
	Photo scale 1:20,000
	Vertical 60% overlap
	Direction of flight - West to East
	Date 10.6.68

APPENDIX 6.3

LOCATION OF AIR-PHOTOS FLOWN FOR THIS STUDY IN THE TALBIGHAH AND SUWANI BIN YADIM REGIONS, AND THE DISPOSITION OF HEIGHT CONTROL POINTS BY LEVELLING IN THE TALBIGHAH REGION.



◂ BENCH MARK

LOCATION OF HEIGHT CONTROL POINTS 1 - 6 ▾

See previous page

APPENDIX 7.1 Underground - water Levels and Rainfall at Mellahah (near Talbighah) and Suwani bin Yadim 1959 - 1968

Mellahah — Well No 1374 - 352/M.4 — Depth Surface to Water; Rainfall

April 1960 - August 1968

Depth Surface to Water (Metres)

	J	F	M	A	M	J	J	A	S	O	N	D
1960				7.66		7.84	7.90	7.84	7.88	7.70	7.64	7.58
1961	7.38	7.44	-	7.64	7.69	7.70	7.87	7.88	7.86	7.88	7.68	7.63
1962	7.52	7.54	7.59	7.73	7.79	7.86	7.86	7.93	7.90	7.84	7.55	7.57
1963	7.52	7.54	7.58	7.71	7.74	7.82	7.91	8.02	7.94	7.68	7.51	7.48
1964	7.63	7.49	7.53	7.75	7.83	7.85	7.91	7.95	7.94	7.58	7.59	7.51
1965	7.51	-	7.60	7.68	7.85	8.02	8.06	8.04	7.87	7.78	7.69	7.60
1966	7.56	7.63	7.58	7.81	7.88	8.08	8.00	-	7.92	7.79	7.63	7.58
1967	7.48	7.59	7.72	7.75	7.89	-	-	7.98	7.98	7.78	7.67	7.55
1968	7.51	7.63	7.59	7.90	-	7.88	8.01	8.04	-	-	-	-

Rainfall (Millimetres)

	J	F	M	A	M	J	J	A	S	O	N	D
1960				45.0	1.0	0	0	0	41.0	3.0	31.7	219.0
1961	35.6	8.5	31.7	49.0	7.0	0	0	0	0	19.0	0	25.0
1962	62.0	81.5	62.0	3.3	0	0	0	0	0.2	32.6	26.0	81.5
1963	55.0	9.5	26.0	14.0	0	0	0	0	59.5	104.2	15.0	6.5
1964	136.0	29.5	0	4.4	0	0	0	0	3.5	1.2	86.0	30.5
1965	70.0	27.5	28.2	9.5	0	0	0	2.5	10.0	12.0	9.0	56.0
1966	12.0	11.3	54.5	58.0	0	0	0	0	3.2	73.0	26.0	127.0
1967	112.0	12.7	65.0	1.5	0	0	0	0	0	29.5	64.0	90.0
1968	62.0	50.5	4.0	0	0	0	0	0				

Note: The well and the rain gauge were within one kilometre

Estimates underlined

Suwani bin Yadim — Well No 3242 - 1302 - 1

March 1959 - August 1968

Depth Surface to Water (Metres)

	J	F	M	A	M	J	J	A	S	O	N	D
1959	-	-	11.41	11.53	11.56	11.61	11.70	11.78	11.81	11.90	11.88	11.88
1960	11.88	11.91	11.94	11.98	11.93	12.09	12.18	12.30	12.41	12.39	12.44	12.38
1961	12.35	12.32	12.31	12.38	12.46	12.53	12.60	12.67	12.73	12.78	12.83	12.86
1962	12.82	12.74	12.67	12.71	12.80	12.89	12.92	12.98	13.02	13.04	13.02	12.94
1963	12.92	12.92	12.94	12.97	13.06	13.11	13.20	13.30	13.36	13.33	13.35	13.36
1964	13.33	13.26	13.29	13.38	13.42	13.50	-	-	-	-	-	-
1965				13.75	13.82	13.99	14.06	14.22	14.29	14.33	14.36	14.34
1966	14.36	14.42	14.44	14.50	14.60	14.75	14.94	15.09	15.19	15.23	15.25	15.18
1967	15.12	15.19	15.31	15.50	15.70	-	16.19	16.22	16.31	16.40	16.35	16.31
1968	16.26	16.23	16.32	-	16.65	16.89	17.19	17.41				

Rainfall (Millimetres)

	J	F	M	A	M	J	J	A	S	O	N	D
1959			14.5	5.5	0	0	0	0	0	31.0	16.5	44.0
1960	5.5	4.8	3.0	21.5	0	0	0	0	6.0	0	27.0	71.0
1961	17.5	17.0	21.0	24.0	0	0	0	0	11.0	7.0	0	7.0
1962	105.0	67.8	15.0	8.0	3.0	0	0	0	2.0	27.5	27.0	96.0
1963	39.0	11.0	10.0	16.8	0	0	0	0	76.0	102.0	41.0	0
1964	182.0	76.0	0	3.0	0	4.0	0	0	0	9.0	29.5	2.0
1965	26.5	28.0	13.0	3.0	0	0	0	0	10.0	4.0	5.0	38.0
1966	19.0	10.0	35.0	74.0	0	0	0	0	15.0	30.5	47.0	65.0
1967	75.0	10.5	73.0	3.0	5.0	4.0	0	0	6.5	27.0	17.0	41.0
1968	44.5	34.5	20.0	18.0	0	0	0	0				

'-' indicates no data available

Note: The well and the rain gauge were within half kilometre

Source: Water levels from Ministry of Agriculture, Soil and Water Conservation Department.
Rainfall data from Ministry of Communications, Department of Meteorology and from farm records.

APPENDIX 7.2 Comparison of Underground-water Level & Rainfall Data for Suwani bin Yadim 1959-1968
(Rain gauge & observation well within one kilometre)

All figures in metres

		J	F	M	A	M	J	J	A	S	O	N	D	Total Winter Rain
1959	Well*			11.41	11.53	11.56	11.61	11.70	11.78	11.81	11.90	11.88	11.88	
	Rain+	.033	.055	.015	.006	0	0	0	0	0	.031	.017	.044	+ 0.126
1960	Well	11.88	11.91	11.94	11.98	11.93	12.09	12.18	(12.30)	(12.41)	12.39	12.44	12.38	
	Rain	.006	.005	.003	.022	0	0	0	0	.006	0	.027	.071	0.184
1961	Well	12.35	12.32	12.31	12.38	12.46	12.53	12.60	12.67	12.73	12.78	12.83	12.86	
	Rain	.018	.017	.021	.024	0	0	0	0	.011	.007	0	.007	0.224
1962	Well	12.82	12.74	12.67	12.71	12.80	12.89	12.92	12.98	13.02	13.04	(13.02)	12.94	
	Rain	.105	.068	.015	$.008^{x}$	.003	0	0	0	.002	.028	.027	.096	0.229
1963	Well	12.92	12.92	12.94	12.97	13.06	13.11	13.20	13.30	13.36	13.33	13.35	13.36	
	Rain	.039	.011	.010	.017	0	0	0	0	.076	.102	.041	0	0.484
1964	Well	(13.33)	13.26	13.29	13.38	(13.42)	13.50	-	-	-	-	-	-	
	Rain	.182	.076	0	.003	0	.004	0	0	0	.009	.030	.002	0.111
1965	Well	-	-	-	(13.75)	13.82	13.99	14.06	14.22	14.29	14.33	14.36	14.34	
	Rain	.027	.028	.013	.003	0	0	0	0	.010	.004	.005	.038	0.195^{x}(estimated)
1966	Well	14.36	14.42	14.44	14.50	14.60	14.75	14.94	15.09	15.19	15.23	15.25	15.18	
	Rain	.019	$.010^{x}$	.035	.074	0	0	0	0	.015	.031	.047	.065	0.328
1967	Well	15.12	15.19	15.31	15.50	15.70	-	(16.19)	16.22	16.31	16.40	16.35	16.31	
	Rain	.075	.011	.073	.003	.005	.004	0	0	.007	.027	.017	.041	0.209
1968	Well	16.26	16.23	16.32	-	16.65	16.89	17.19	17.41					
	Rain	.045	.035	.020	.018	0	0	0	0	0				

* metres below surface   + rainfall in decimals of a metres. .033 metres = 33 mm.

\- no data available   x estimated from figures for Ben Gashir (Idris) - 8 km distant.

Source:: Rainfall data from unpublished records of the Ministry of Communications, Meteorological Department

Groundwater data from Ministry of Planning, Soil and Water Conservation Department
\- Records for Well No 3242.1302.1.

APPENDIX 7.3 Comparison of Underground-water Level Data for Observation Well 1374.352.M-4 at Mellahah and Rainfall Data from the Gauge at the North End of the Gargour Farm

All Figures in Metres

		J	F	M	A	M	J	J	A	S	O	N	D	Total Winter rain
1960	Well*				7.66	-	7.84	7.90	7.84	7.88	7.70	7.64	7.58	+ .428
	Rain+									.041	.003	.032	.219	
1961	Well	7.38	7.44	-	7.64	7.69	7.70	7.87	7.88	7.86	7.88	7.68	7.63	.253
	Rain	.036	.009	.032	.049	.007	0	0	0	0	.019	0	.025	
1962	Well	7.52	7.54	7.59	7.73	7.79	7.86	7.86	7.93	7.90	7.84	7.55	7.57	.248
	Rain	.062	.082	.062	.003	0	0	0	0	.002	.033	.026	.082	
1963	Well	7.52	7.54	7.58	7.71	7.74	7.82	7.91	8.02	7.94	7.68	7.51	7.48	.356
	Rain	.055	.010	.026	.014	0	0	0	0	.060	.104	.015	.007	
1964	Well	7.63	7.49	7.53	7.75	7.83	7.85	7.91	7.95	7.94	7.58	7.59	7.51	.261
	Rain	.136	.030	0	.004	0	0	0	0	.004	.001	.086	.031	
1965	Well	(7.51)	-	7.60	7.68	7.85	8.02	8.06	8.04	7.87	7.78	7.69	7.60	.223
	Rain	.070	.028	.028	.010	0	0	0	.003	.010	.012	.009	.056	
1966	Well	7.56	7.63	7.58	7.81	7.88	8.08	8.00	-	7.92	7.79	7.63	7.58	.421
	Rain	.012	.011	.055	.058	0	0	0	0	.003	.073	.026	.127	
1967	Well	7.48	7.59	7.72	7.75	7.89	-	-	7.98	7.98	7.78	7.67	7.55	.301
	Rain	.112	.013	.065	.002	0	0	0	0	0	.030	.064	.090	
1968	Well	7.51	7.63	7.59	7.90	-	7.88	8.01	8.04	7.92				
	Rain	.062	.051	.004	0	0	0	0	0	0	.096			

* metres below the surface + rainfall in decimals of a metre - .033 metres = 33 mm.

'-' no data available

Note: The rain gauge and the observation well were 2 km. apart approximately

Source : Rainfall as Appendix 7.2
Groundwater data as Appendix 7.2 but for Well 1374.353.M-4.

APPENDIX 7.4 Comparison of Annual and Seasonal Drawdown with Precipitation - Talbighah/Mellahah - 1960-1968

All Figures in millimetres

		Talbighah fluctuations in groundwater levels				Rainfall Recording Stations Around the Talbighah Area			
		Metres below surface (Sep) A	Annual change (Sep-Sep) B (Al - Azete)	(Jan) C	Seasonal change (Jan-Sep) D (C-A)	Gargour Rain mm. E	Suq al Jumah	Tanrah	Tripoli
Sep 60	1	7.88							
Jan 61			(+0.02)*	7.38		428	303	367	473
Sep 61	2	7.86			-0.48				
Jan 62			(-0.04)	7.52		253	219	249	282
Sep 62	3	7.90			-0.38				
Jan 63			(-0.04)	7.52		248	225	241	216
Sep 63	4	7.94			-0.42				
Jan 64			(0)	7.63		356	409	370	356
Sep 64	5	7.94			-0.33				
Jan 65			(+0.07)	7.51		261	144	198	214
Sep 65	6	7.87			-0.36				
Jan 66			(-0.05)	7.56		223	-	214	179
Sep 66	7	7.92			-0.36				
Jan 67			(-0.06)	7.48		-	-	342	272
Sep 67	8	7.98			-0.40				
Jan 68			(+0.06)	7.51		-	-	193	199
Sep 68	9	7.92			-0.41				
Mean overall annual change			-0.04	-0.13					

'-' indicates no data available

* '+' = rise, '-' = fall

Source: Groundwater - Observation Well No 1374.352.M-4
Ministry of Agriculture, Soil and Water Conservation Department.
Rainfall - Unpublished records, Ministry of Communications, Meteorological Department, Tripoli

Notes: The above figures confirm that local precipitation is not the most important factor in maintaining groundwater levels. Recharge from outside is a more important factor.

Gross Domestic Product at Current Price by Source 1962 to 1968

Source	1962	1963	1964	1965	1966	1967	1968
	Million Libyan Pounds						
Agriculture, forestry, fishing	15.0	15.2	16.7	25.3	27.5	30.7	33.0
Petroleum mining	34.6	87.7	197.5	272.3	345.8	405.2	655.2
Other mining and quarrying	0.6	0.7	0.8	1.0	1.1	1.3	1.5
Manufacturing	9.0	9.9	11.5	12.6	14.4	16.4	20.0
Construction	10.9	13.2	23.0	35.2	46.2	68.2	91.1
Electricity, gas	0.9	1.1	1.3	1.6	1.9	2.3	3.0
Transport and communications	8.2	10.8	14.3	17.7	23.6	30.1	37.6
Wholesale and retail trade	14.7	18.6	28.2	33.4	42.4	49.2	62.6
Banking and insurance	1.7	2.8	5.2	7.0	8.7	10.5	13.0
Public administration and Defence	15.0	18.9	25.3	35.5	44.8	54.6	69.7
Educational services	5.1	7.1	9.6	13.1	16.8	20.4	26.5
Health services	2.1	2.6	3.4	4.5	6.4	7.7	10.8
Ownership of dwellings	29.4	30.8	33.4	36.4	43.6	53.6	59.7
Other services	5.3	6.1	7.1	8.5	9.9	10.7	11.6
GDP at factor cost	152.5	225.5	377.3	504.1	633.1	760.9	1095.3
Net income sent abroad	6.8	10.1	77.3	81.6	106.9	128.3	228.9
GDP at factor cost	145.7	215.4	300.0	422.5	526.2	632.6	866.4
Less depreciation	14.3	21.4	28.6	38.6	47.2	59.0	68.6
National Income	131.4	194.0	271.4	383.9	479.0	573.6	797.8

GDP = Gross Domestic Product

GNP = Gross National Product

Source: Census and Statistics Department, Planning Institute, Libyan Arab Republic Survey of National Economy Tripoli, undated, p. 48.

Expenditure of Libyan Government 1963/64 to 1968/69

(Ordinary Budget)

Head of Expenditure	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69
	(Expenditure in thousand Libyan Pounds)					
Administration Defence etc.						
Interior	5,917	10,333	14,078	15,925	18,470	30,606
Municipal Affairs	306	955	721	750	1,103	3,200
Defence	4,323	6,003	7,348	17,254	14,964	14,242
Justice	692	995	1,404	1,809	2,108	3,494
Other	3,885	5,609	8,683	9,792	10,992	14,903
Social Services						
Education[a/]	9,059	12,020	16,845	19,983	23,990	33,585
Health	3,099	4,488	6,462	10,246	9,268	13,934
Other	963	1,515	2,144	4,896	3,289	5,841
Transport, Communications						
Roads	1,834	1,626	1,712	1,718	1,656	1,981
Posts & Telecommunications	1,854	2,333	2,477	2,969	2,690	4,738
Other	3,446	5,047	4,226	5,415	5,955	9,093
Production						
Agriculture etc.	2,687	2,595	3,402	4,492	4,483	5,417
Industry & Petroleum	626	588	736	554	1,422	1,694
Works	2,255	3,134	3,505	5,990	5,446	7,147
Housing / State Property	1,391	2,899	1,221	6,772	8,945	7,429
Miscellaneous	3,299	4,087	7,508	4,217	6,709	4,752
Total	46,136	64,227	82,992	112,782	121,490	162,061
National Defence & Arab Support	-	-	-	-	15,000	70,904
Allocation to Development	16,681	38,301	57,978	92,294	119,705	193,885
To Reserve	-	-	-	10,000	20,000	33,100
Grand Total	62,817	102,528	140,970	215,076	276,195	459,952

a/ Excludes antiquities

Source: Census and Statistics Department, Planning Institute, *Libya Arab Republic Survey of Natural Economy*, Tripoli, undated, p. 123 - 124.

Expenditures per Farm According to Type of Farming

Data for 371 Farms in All Settled Agricultural Areas of Western Libya-1967/68

Percentage Distribution of Investment by Item

All Figures are percentages except those for Total Expenditure

	Traditional (163)* %	Modern (207)* %	Irrigated and Semi-irrigated (276)* %	Non-irrigated (94)* %
% of total farms	44	56	75	25
% of total cult'd area	18	82	81	19
Real property and construction	58	37	40	51
(Homes & rooms)	(48)	(19)	(22)	(39)
Irrigation Equipment	13	31	30	6
Machinery	15	20	18	28
Transport	12	9	9	13
Land Reclamation	2	3	3	3
Total Investment	100	100	100	100
Other Expenditure	8	5	6	6
Total Expenditure	£L 771	£L 2561	£L 2093	£L 839

Notes 1. 'Real Property and construction' includes 'homes and rooms', and this last item should not be counted twice in making up total investment.

2. 'Other Expenditures' are expressed as percentages of 'Total expenditure'.

3. Percentages may have rounding errors.

* Number of farms shown in brackets.

Source: Dasgupta, B. K., 'Investment in Libyan Agriculture' in Penrose, E. T., Allan, J.A. and McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970, p. 149.

Appendix 10.2

Expenditure per Farm According to Size and Items of Expenditure for

77 Farms in the Tripoli Muhafadah - 1967/68

Percentage Distribution of Investment by Item

All Figures are Percentages except those for Total Expenditure

	Small (54)*	Medium (12)*	Large (6)*	V.Large (6)*	Total (77)*
% of total farms	69%	15%	8%	8%	100%
% of total cultivated area	1%	4%	10%	55%	100%
Hectares	0 - 20 ha.	21 - 80 ha.	81 - 350 ha.	>350 ha.	-
Real property & construction	51%	50%	35%	3%	44%
(Homes & rooms)	(27)	(0)	(19)	(0)	(16)
Irrigation Equipment	30	41	37	50	36
Machinery	10	3	16	15	10
Transport	6	1	7	31	6
Land Reclamation	4	5	5	2	4
Total Investment	100	100	100	100	100
Other Expenditure	10	1	1	1	5
Total Expenditure	£L 2077	£L 5536	£L 11270	£L 1991	£L 3336

Notes 1. 'Real property and construction' includes 'homes and rooms', and this last item should not be counted twice in making up total investment.

2. 'Other Expenditures' are expressed as percentages of 'Total Expenditure'.

3. Percentages may contain rounding errors. * Number of farms in brackets.

Source: Dasgupta, B. K., 'Investment in Libyan Agriculture' in Penrose, E.T., Allan, J. A., and McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970, p. 152.

Expenditure per Farm According to Size and Items of Expenditure for

ZAWIYAH Western Libya 1967/68

Percentage Distribution of Investment by Item

All Figures are Percentages except those for Total Expenditure

	Small (86)*	Medium (12)*	Large (6)*	V.Large (2)*	Total (106)*
% of total farms	81%	11%	6%	2%	100%
% of total cultivated area	35%	10%	22%	33%	100%
Hectares	0 - 20 ha.	21 - 80 ha.	81 - 350 ha.	350 ha.	-
Real property and construction	59%	43%	6%	0%	42%
(Homes and rooms)	(48)	(4)	(6)	(0)	(29)
Irrigation Equipment	11	26	65	3	25
Machinery	16	21	25	85	22
Transport	12	9	4	9	9
Land Reclamation	2	2	1	3	1
Total Investment	100	100	100	100	100
Other Expenditure	13	3	0	5	8
Total Expenditure	£L 1394	£L 2715	£L 7012	£L 4747	£L 1924

Notes 1. 'Real property and construction' includes 'homes and rooms', and this last item should not be counted twice in making up total investment.

2. 'Other Expenditures' are expressed as percentages of 'Total Expenditure'.

3. Percentages may have rounding errors.

* Number of farms in brackets.

Source: Dasgupta, B. K., 'Investment in Libyan Agriculture' in Penrose, E.T., Allan, J.A. and McLachlan, K.S., Agriculture and the Economic Development of Libya, London, 1970, p. 151.

Appendix 11

RETAIL PRICE INDEX FOR FOOD GROUP IN TRIPOLI TOWN

January 1955 = 100

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1955	100	99	101	96	93	93	100	105	104	103	109	115
1956	109	111	111	114	111	112	109	108	116	112	109	106
1957	107	104	109	106	100	103	101	102	105	110	112	114
1958	111	110	118	114	108	108	108	111	112	111	111	112
1959	114	112	111	114	111	113	109	118	125	124	122	124
1960	128	127	129	126	127	127	125	125	129	139	135	136
1961	136	138	134	129	124	126	122	125	126	129	126	136
1962	133	129	134	132	129	132	127	133	140	143	144	144
1963	149	146	140	143	143	140	140	141	145	147	146	146
1964	146	145	145	149	145	148	150	152	153	158	158	155
1965	161	157	148	159	161	157	145	144	161	165	165	166
1966	173	176	179	183	175	179	162	169	183	193	189	197
1967	204	199	201	202	199	168	160	162	170	179	179	178
1968	176	178	180	197	201	198	189	190	214	208	203	196

Up to December 1963, the figures represent the old price index of some food items in Tripoli.

From January 1964 the figures are those of the new price index of food group after being linked to the old series, January 1955 = 100.

Source: Census and Statistics Department, Ministry of Planning.

Time Series of the Median of Agricultural Wages
Derived From the Accounts of a Farm Close to Tripoli
(180 Ha. 40 Permanent Employess Approximately)

	WAGE £ Libyan	INDEX
1953	0.135	100
54	0.140	103
55	0.140	103
56	0.145	107
57	0.150	111
58	0.170	126
59	0.180	133
60	0.250	185
61	0.300	222
62	0.300	222
63	0.300	222
64	0.400	296
65	0.500	370
66	0.600	444
67	0.650	481
68	0.800	592

Source: Farm accounts of Gargour et Fils 1953-1968
made available to the author.

Appendix 13.1

National Agricultural Bank of Libya

Loans Approved & Loans Paid Out

			57/58	58/59	59/60	60/61 £L	61/62 '000	62/63	63/64	64/65	65/66	66/67	67/68
Short Term Loans	Approved	No	2143	4917	2620	3455	6551	8101	7495	6657	7424	8445	8772
		£L	429	751	298	391	649	835	756	698	871	1073	1097
	Paid	No	-	-	-	-	-	6848	7467	6723	7135	8100	8510
		£L '000	310	530	279	331	528	638	672	659	803	992	1056
Medium Term Loans	Approved	No	0	0	0	0	281	1376	1203	1417	2337	3484	2273
		£L '000	0	0	0	0	98	429	449	406	928	1832	676
	Paid	No	0	0	0	0	183	1100	1089	1380	1957	3547	2013
		£L '000	0	0	0	0	60	363	412	384	726	1692	613
Long Term Loans	Approved	No	0	0	0	588	636	397	120	0	0	947	1044
		£L '000	0	0	0	695	757	399	109	0	0	2090	1000
	Paid	No	0	0	0	417	608	391	267	8	0	8	-
		£L '000	0	0	0	457	802	423	229	6	0	992	981
Total	Approved	No	2143	4917	2620	4043	7468	9874	8818	8074	9761	12876	12088
		£L	429	591	298	1086	1504	1663	1312	1104	1799	4995	2773
	Paid	No	-	-	-	-	-	8339	8821	8111	9092	16658	10424
		£L	310	530	277	788	1390	1424	1313	1049	1529	3676	2650

Loans Outstanding (£L '000)

	57/58	58/59	59/60	60/61	61/62	62/63	63/64	64/65	65/66	66/67	67/68
Short Term Loans	366	666	633	651	593	850	1026	1121	1822	1960	3707
Medium Term Loans	0	0	0	24	80	408	744	854	922	1325	2656
Long Term Loans	0	0	0	458	1185	1500	1615	1553	1509	1407	2269
Total	366	666	633	1133	1858	2758	3385	3528	4253	4692	8432

Source: Bank of Libya Economic Bulletin May - June 1970.

'-' = not available

Ordinary and Development Expenditure

'000,000

ORDINARY BUDGET	6.3	7.6	8.0	9.1	10.3	12.1	15.7	17.8	18.6	28.1	35.4	43.4	53.3	79.0	86.9
DEVELOPMENT BUDGET	.3	.6	.8	3.9	5.1	4.9	4.3	2.8	9.7	6.4	9.0	21.7	32.6	86.8	90.0
Total	6.6	8.2	8.8	13.0	15.4	17.0	20.0	20.6	28.3	34.5	44.4	65.1	85.8	165.8	177.9

Source: Bank of Libya, Statistical Supplement, Tripoli July 1967.

Public Expenditure by Main Categories

£L '000,000

	52/53	53/54	54/55	55/56	56/57	57/58	58/59	59/60	60/61	61/62	62/63	63/64	64/65	65/66	66/67
GENERAL ADMINISTRATION AND DEFENCE															
1. Law and Order	1.1	1.1	1.5	1.7	2.0	2.2	2.4	2.5	2.5	3.5	4.4	5.6	10.5	14.0	15.2
2. Tax Collection	.05	.1	.2	.2	.2	.2	.3	.3	.4	.5	.7	.6	1.2	1.5	1.5
3. Development Administration	.02	.02	.04	.07	.1	.3	.3	.3	.4	.2	.1	.7	.5	1.1	1.0
4. Other Civil Administration	1.5	1.7	1.4	1.8	2.0	2.0	3.2	3.6	3.8	7.2	7.3	9.4	16.7	25.1	16.9
5. Public Buildings and Equipment	.01	0.2	0.5	0.5	0.7	1.3	1.6	1.3	0.8	1.7	1.9	2.9	3.4	4.7	10.5
6. Defence	.06	.2	.3	.4	.5	.6	1.1	1.4	1.4	1.9	2.5	4.1	6.7	7.7	9.3
SOCIAL SERVICES Total	2.7	3.5	4.0	4.6	5.5	6.6	8.8	9.3	9.2	15.1	16.9	22.0	37.3	52.1	52.2
7. Health	.5	.6	.6	1.0	1.5	1.4	1.6	1.7	2.0	2.7	3.0	3.9	6.4	9.3	9.8
8. Education	.6	.9	1.2	1.3	1.7	2.5	3.4	3.6	4.1	5.4	6.0	10.9	14.6	24.4	25.9
9. Relief and Welfare (Including Housing)	.2	.3	.4	.2	.3	.4	.3	.3	.3	.6	.9	3.8	4.1	11.8	19.9
10. Municipalities	.2	.2	.4	.4	.4	.4	.3	.4	.4	.7	1.4	.8	1.1	4.2	3.2
11. Miscellaneous	-	-	-	-	-	-	-	-	-	-	-	1.0	3.6	5.6	9.5
ECONOMIC SERVICES Total	1.5	2.0	2.6	2.9	3.9	4.7	5.6	6.0	6.9	9.4	11.2	20.5	29.9	55.3	68.3
12. Agriculture & Irrigation	.3	.4	.6	1.9	2.2	1.8	1.4	1.7	2.6	2.8	2.0	4.5	6.2	11.8	10.8
13. Industry and Minerals	-	-	.02	.1	.07	.06	.06	.03	.3	.4	.1	.8	1.7	4.9	5.9
14. Tourism & Antiquities	.02	.03	.05	.06	.09	.05	.07	.07	.08	.1	.1	.4	.8	1.5	2.1
15. Transport & Communications	2.0	2.2	1.4	1.7	2.3	2.9	3.6	3.1	5.8	5.2	4.7	8.9	15.0	28.2	21.4
16. Electricity and Water Supplies	.05	.2	.1	1.0	1.4	1.0	.3	.2	1.8	.7	.3	4.8	6.7	9.7	9.0
17. Miscellaneous	-	-	-	-	-	-	-	-	-	-	-	2.0	1.4	6.4	6.1
Total	2.4	2.8	2.2	5.5	6.0	5.7	5.6	5.2	12.2	10.0	7.3	21.3	31.8	62.5	55.2
Grand Total	6.6	8.2	8.8	13.0	15.4	17.0	20.0	20.6	28.3	34.5	35.4	65.2	100.8	171.8	177.9

Appendix 14

Details of the Variable Definitions Used in Section 5.3.1(2)

The following is a list of the variables used in the simple correlation and principal components analysis, with outline definitions and explanations where relevant. Similar and consistent definitions were used in the field by enumerators. Except where indicated the data recorded refer to July 1968, or to the period July 1967 - July 1968.

1. Per cent cultivated

The total area cultivated in 1967/68, including both dry and irrigated plots, expressed as a percentage of the total area of the holding, the holding being defined as the total area of all parcels owned or managed by the respondent.

2. Per cent cereals

As for '1' above, but with respect to cereals. Cereals include wheat, barley and oats grown almost exclusively as dry-land crops. A minor area would be that of maize and millets, which as summer crops in Libya were normally irrigated. The latter areas were relatively small, however, and the area under cereals can be taken to be an indicator of dry or marginally irrigated farm land. The areas under summer cereals were recorded in the field, and those for winter cereals were recorded either by noting the areas recently gathered which were then checked with the farmer.

3. Per cent vegetables

As for '1' above, but with respect to vegetables. The area under vegetables was recorded in the field for the summer of 1968, and the respondents recollection of the preceding winter's vegetables. Vegetables included the following:-

1. Broad beans	5. Potato	9. Cauliflower	13. Lettuce
2. Runner beans	6. Turnip	10. Artichoke	14. Onion
3. Peas	7. Radish	11. Tomato	
4. Carrot	8. Cabbage	12. Cucumber	

It should be noted that alfalfa and melons were not included as vegetables.

4. Per cent irrigated

As for '1' but with respect to the area irrigated with water raised by animal or mechanical means and distributed by traditional 'basin' methods or by sprinkler equipment.

5. Electric pumps per hectare

The total number of electric pumps per hectare in relation to the area of the whole farm. It should be noted that the power of the pumps has not been taken into account. This varied from less than one horse power to over 10 horse power, thus favouring the smaller farm in terms of providing indices of irrigation activity.

6. Diesel pumps per hectare

As for '5' with respect to diesel pumps.

7. Expenditure (A) per hectare

This variable was intended to be an indicator of the expenditure in the period July 1967 - July 1968 on dwellings and/or extension of dwellings. Expenditure on building materials for such purposes was also taken into account. Such expenditure was especially vigorous on type 1 farms, and it was felt to be important to isolate such spending in any numerical analysis of the data. The variable has been expressed in terms of the total area of the farm.

8. Expenditure (B) per hectare.

Expenditure (B) consists of such items of expenditure as spending on furniture, weddings and travel and upon private motor vehicles. The first three expenditures could not be regarded as contributions to farm improvement, and although a motor car may have had a secondary use for farm purposes it was observed that these vehicles were used mainly for private purposes. This variable expresses something of the direction of spending on major items not directly concerned with the running of the farm or its improvement. It reflects the disposal of capital surplus to farm requirements. The variable has been expressed in terms of the total area of the farm for the period July 1967 - July 1968.

9. Rooms per resident

The total number of rooms expressed in terms of the total number of residents related to the respondent living on the farm in July 1968. This was felt to be a crude indicator of standard of living.

10. Length of occupation

The length of occupation of the holding by the owner, tenant or manager.

11. Sheep and goats per hectare

The area of settled agriculture treated in this study was not strongly orientated towards livestock rearing. Such rearing is carried out in more marginal areas. Nevertheless it was felt to be important to include one variable relating to livestock. Sheep and goats of all ages were included in the definition provided they were being reared on the holding at the time of the study (July 1968).

12. Spray pipes per hectare

The spray method of irrigation was probably the most important signifier of progressive attitudes. The length of spray pipes was enumerated in metres and expressed in terms of the total area of the farm. Only pipes above the surface of the ground have been included.

13. Tractors per hectare

The total tractors owned by the farmer in July 1968 expressed in terms of the total area of the farm. The size and capacity of the tractors has not been taken into account and so the smaller units with relatively small tractors have been favoured in terms of the intensity of tractor availability.

14. Permanent workers per hectare

All workers, male, female and boys, including residents have been included. Often the number varied somewhat through the year. The number recorded were those employed at the date of the study, July 1968.

15. Level of education

The level of education of the owner, tenant or manager was recorded on the following scale:-

1. Never been to school
2. Has been to primary school
3. Has been to secondary school
4. Has been to university
5. Professional training

16. Residents per hectare

The total number of residents living on the farm at the time of the survey were recorded. All kin of the owner, tenant or manager were taken into account. Workers living in temporary dwellings, for example 'squatters' from Tunisia, were not enumerated.

17. Farm area (hectares)

The total area of all parcels which could be identified as a management unit was recorded. The plot or plots might be owned, let or managed by the respondent.

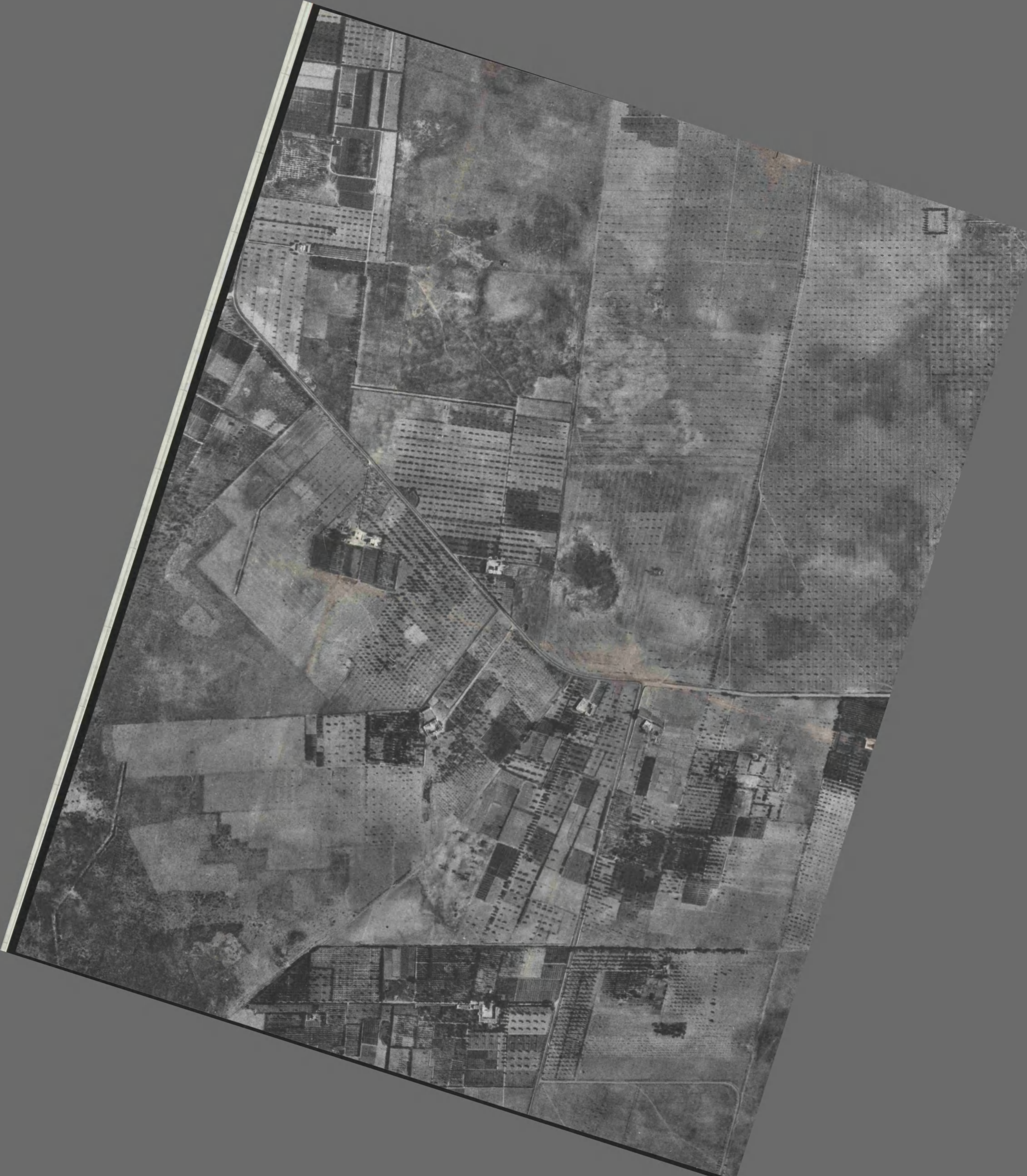
18. Mean parcel size (hectares)

The number of separate plots owned, rented or managed by the respondent were recorded. The total area of all farms was divided by the total number of parcels to give mean parcel size. This variable gives no measure of the degree of separateness of the plots.

19. Investment per hectare

This variable is concerned with the total investment on the farm which could have a direct bearing on the running of the farm or upon its improvement. For this purpose all the expenditure on housing (Expenditure A), on other buildings and equipment, upon well deepening, young trees, land and all forms of transport, including private cars. It should be noted that spending on furniture, weddings and travel have been excluded.

TALBIGHAH 1.1 1953



TALBIGHAH 1.2 1953

TALBIGHAH 1.3 1953

AERO EXPLORATION
Frankfurt am Main
Germany

Scale approx. 1 : 5000

1:50

TALBIGHAH 2.1 1968

AERO EXPLORATION
Frankfurt am Main
Germany

Scale approx. 1 : 5000

TALBIGHAH 2.2 1968

SUWANI BIN YADIM 3 1953


1:5000 APPROX

SUWANI BIN YADIM 4 1968